Biological Assessment Report

West Fork Locust Creek

Sullivan County, Missouri

Fall 2016 and Spring 2017

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

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Appendix A Fall 2016 Macroinvertebrate Taxa Lists, West Fork Locust Creek

Appendix B Spring 2017 Macroinvertebrate Taxa Lists, West Fork Locust Creek

1.0 Introduction

The quality of benthic macroinvertebrate communities is largely determined by instream habitat, and habitat management issues are often a challenge in agricultural streams. One aspect of habitat includes riparian zones. Large vegetation with substantial roots to stabilize banks encompass high-quality riparian zones because, ultimately, stable channels protect instream habitat. For example, in agriculturally influenced streams, macroinvertebrate diversity and the percentage of insects increase with the quantity of tree cover in the riparian zone (Stone et al. 2005). Trees in the riparian zone also decrease silt quantities in the stream channel, and silt poses a problem for macroinvertebrates by filling interstitial habitat spaces in the substrate (Stone et al. 2005) and interfering with respiration (Lemly 1982). It is the filtration function of large, stable vegetation in the riparian zone that improves general water quality issues in streams (Moore and Palmer 2005).

In addition to habitat challenges, streams in agricultural landscapes receive nutrient and pesticide runoff from adjacent fields. Although instream habitat determines most variation in macroinvertebrate communities, nutrients explain 22 percent of this variation (Wang et al. 2007). Generally, sensitive orders (Ephemeroptera, Plecoptera, and Trichoptera) and taxonomic richness decline and biotic index values increase as nitrogen and phosphorus concentrations increase (Wang et al. 2007). In addition to nutrient applications, livestock with access to streams and runoff through confined animal feeding operations (**CAFO**s) both contribute to high nutrients in the water column (Knowlton and Ray 2013). These nutrients can drastically increase primary production and result in hypoxic conditions as well as increased fecal coliform bacteria (Burkholder et al. 2007). Coupled with nutrients in agricultural systems are pesticides. Moderate applications of insecticides into the catchment of a headwater stream drastically decrease the shredder functional feeding group (**FFG**) of macroinvertebrates (Liess and Schulz 1999). Shredders are the primary functional feeding group capable of making coarse woody debris available to downstream organisms and to the remainder of the food chain (Wallace and Webster 1996, Vannote et al. 1980). Nutrient applications (Carpenter et al. 1998), insecticide use (Liess and Schulz 1999), land use (Stone et al. 2005, Lenat and Crawford 1994), and riparian zones (Stone et al. 2005, Moore and Palmer 2005) are critical variables in agricultural streams that can impair water quality and negatively shape the benthic macroinvertebrate community.

1.1 Previous Bioassessment and Analysis of West Fork Locust Creek

The Missouri Department of Natural Resources' (**MoDNR**) Water Quality Monitoring Section (**WQMS**) conducted a bioassessment study of West Fork Locust Creek during the fall 2007 and spring 2008 seasons (MoDNR 2009). Eight stations were sampled, and stations were arranged longitudinally in Linn and Sullivan counties, Missouri. Habitat comparisons were made with Locust Creek in Putnum County. During both seasons, nitrogen and phosphorus-related nutrients were elevated in stations 5 and 6. The most upstream station had the lowest habitat score and did not fall within the 75 percent similarity to the reference stream. Upstream stations generally scored poorer than

downstream stations and had lower taxa richness and biotic index scores. Stream size, drought, and unknown impairments were suggested as possible drivers behind low MSCI scores in the Class C part of the West Fork Locust Creek stations (MoDNR 2009).

1.2 Purpose of Bioassessment Study

The MoDNR Water Protection Program directed the Environmental Services Program's (**ESP**) WQMS to conduct a follow-up assessment of West Fork Locust Creek in fiscal year 2017. West Fork Locust Creek, water body identification number (**WBID**) 0613, is a Class C stream (may cease flow while maintaining pools to support aquatic life) within and upstream of station 5 (MoDNR 2019d). Station 2, WBID 0612, is a Class P stream (maintains permanent flow even in drought conditions) (Figure 1). West Fork Locust Creek was initially placed on the 303(d) list in 2002 for unknown pollutants. An earlier 2007/2008 bioassessment report indicated extreme environmental conditions may have contributed to low MSCI scores (MoDNR 2009).

1.3 Study Goals

The goal of this study was to assess water quality based on stream habitat, water chemistry, and macroinvertebrate communities in West Fork Locust Creek (**WFL**), Sullivan County, Missouri. To address this goal, five stations were sampled: one station downstream of State Highway ZZ (**WFL8**), one station downstream of Maple Road (**WFL7**), one station downstream of State Highway E (**WFL6**), one station downstream of State Highway PP (**WFL5**), and one station upstream of State Highway MM (**WFL2**) (Figure 1). Samples were collected on September 27-28, 2016, and March 28, 2017. Tasks included the analysis of habitat parameters to compare with reference habitat conditions, water chemistry analyses to determine trends related to the biological community, and an assessment of the macroinvertebrate community to infer biological integrity.

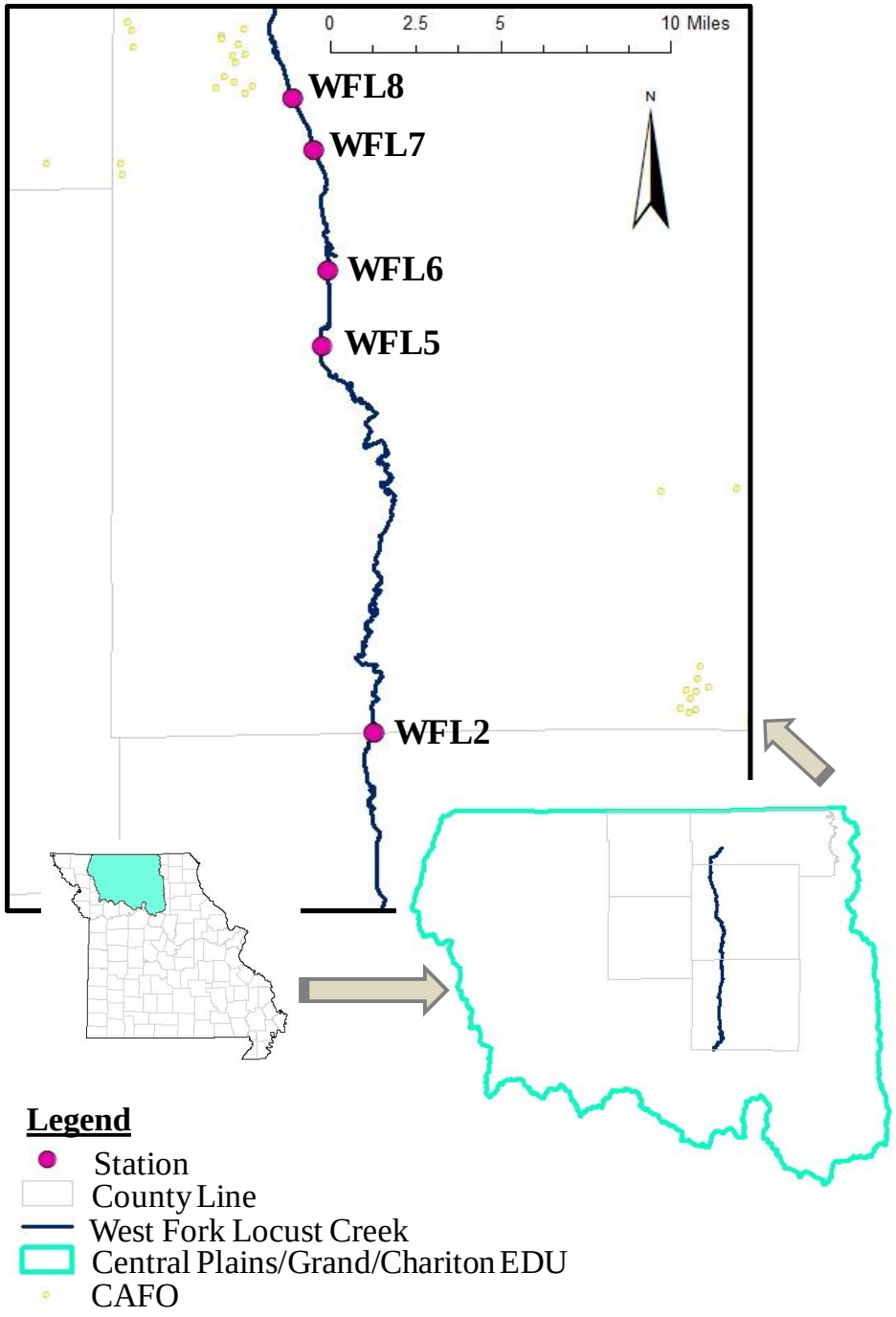

Figure 1. Stations on West Fork Locust Creek, Sullivan County, Missouri.
Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

1.4 Null Hypotheses

1. H_1: Habitat scores will not differ among stations.
2. H_2: West Fork Locust Creek habitat scores will not differ from the reference stream habitat.
3. H_3: Physicochemical measures will not differ among stations.
4. H_4: Physicochemical water quality measures will meet Missouri Water Quality Standards (**WQS**).
5. H_5: Physicochemical water quality measures will meet EPA nutrient criteria recommendations.
6. H_6: The Macroinvertebrate Stream Condition Index (**MSCI**) will indicate benthic communities are the same among stations.
7. H_7: In comparison to the 2007 bioassessment of WFL, stations with a classification of "fully supporting" will not change.

1.5 Study Area

West Fork Locust Creek is located within an agriculturally dominated Ecological Drainage Unit (**EDU**) where corn and soybean crops are prevalent. Cropland covers nearly 30 percent of the Central Plains/Grand/Chariton EDU in comparison to the reference stream, which has only 10 percent cropland (Table 1). Twelve CAFOs are clustered in the northwest portion of the West Fork Locust Creek drainage (Figure 1). The remainder of the land use in the drainage consists of grassland (45 percent) and deciduous forest (14.8 percent) (Table 1).

Table 1. Percent land cover in the West Fork Locust Creek (WFL) study drainage in comparison to the reference stream and the Central Plains/Grand/Chariton EDU drainage.

	Hydrologic Unit Code 12		Central Plains/
	WFL Stations	Reference Stream	Grand/Chariton
Land Cover	102801030803	102802020102	EDU
Impervious	1.3	1.3	2
High Intensity Urban	0	0	0
Low Intensity Urban	0	0.3	0.5
Barren or Sparsely Vegetated	0	0	0.1
Cropland	14.5	10.5	28.3
Grassland	59.1	28.3	45.2
Deciduous Forest	15.2	51.7	14.8
Evergreen Forest	0	0	0
Mixed Forest	0	0	0
Deciduous Woody/Herbaceous	4.1	4.8	3.8
Evergreen Woody/Herbaceous	0	0	0
Woody-dominated Wetland	3.7	2.3	2.8
Herbaceous-dominated Wetland	1.3	0.3	0.9
Open Water	0.9	0.5	1.6

1.6 Station Descriptions

West Fork Locust Creek Station #8 (WFL8) (SE¼ NW¼ sec. 33, T. 64 N., R. 21 W.) was located downstream of the State Highway ZZ bridge in Sullivan County, Missouri. Geographic coordinates for this location in Universal Transverse Mercator (**UTM**) coordinates were UTM Zone 15 UTME 477281, UTMN 4461667.

West Fork Locust Creek Station #7 (WFL7) (NE¼ NE¼ sec. 9, T. 63 N., R. 21 W.) was located downstream of the Maple Road bridge in Sullivan County, Missouri. Geographic coordinates for this location were UTM Zone 15 UTME 478283, UTMN 4459187.

West Fork Locust Creek Station #6 (WFL6) (NE¼ SW¼ sec. 27, T. 63 N., R. 21 W.) was located downstream of the State Highway E bridge in Sullivan County, Missouri. Geographic coordinates for this location were UTM Zone 15 UTME 478974, UTMN 4453509.

West Fork Locust Creek Station #5 (WFL5) (SW¼ SW¼ sec. 3 T. 62 N., R. 21 W.) was located downstream of the State Highway PP bridge in Sullivan County, Missouri. Geographic coordinates for this location were UTM Zone 15 UTME 478745, UTMN 4449927. This station is located in a biological criteria reference reach.

West Fork Locust Creek Station #2 (WFL2) (SW¼ SE¼ sec. 35, T. 61 N., R. 21 W.) was located upstream of the State Highway MM bridge in Sullivan County, Missouri. Geographic coordinates for this location were UTM Zone 15 UTME 481177, UTMN 4431721.

Spring Creek Station #1 (**SC1**) (SW1/4 NE1/4 sec. 3, T.63 N., R. 17 W.) was located south of Highway 171 within the Shoemaker Conservation Area in Adair County, Missouri. Geographic coordinates for this location were UTM Zone 15 UTME 517143, UTMN 4460193.

2.0 Methods

2.1 Stream Habitat

Stream habitat is a foundational filter for aquatic communities and as such determines which species can be supported. Stream habitat was assessed using procedures for glide/pool streams in the *Stream Habitat Assessment Project Procedure* (**SHAPP**, MoDNR 2016c). Stream bed and bank morphology were assessed using 10 habitat measures: epifaunal substrate cover, pool substrate characterization, pool variability, sediment deposition, channel flow status, channel alteration, channel sinuosity, bank stability, bank vegetative protection, and riparian vegetative zone width. Each habitat measure was scored based on a range between zero and 20, in which higher values indicated higher quality habitat conditions. The total habitat score equaled the sum of scores for each habitat measure assessed along 10 separate sections of the stream reach. A stream reach was defined as 20 times the average width of the stream. Scores for each

habitat measure were determined by either an average or selection of the predominant category. The study stream habitat scores were compared to the reference stream habitat scores at Spring Creek in Adair County. Habitat scores were compared between the study stream and the reference stream. Study stream habitat scores that were ≥75 percent of the reference stream habitat score indicated these habitats should be able to support biological communities comparable to the reference stream (MoDNR 2016c).

2.2 Stream Physicochemistry

Water chemistry samples were collected from each of the five sampling stations in accordance with the MoDNR Standard Operating Procedure (**SOP**) *Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2018e). Water parameters were collected as grab samples and included ammonia as nitrogen, total nitrogen, nitrite + nitrate as nitrogen, total phosphorus, chloride, hardness, non-filterable residue, and sulfate. Additional water quality parameters were collected *in situ*, which included temperature (°C) (MoDNR 2018d), specific conductance (µS cm^{-1}) (MoDNR 2018a), dissolved oxygen (mg L^{-1}) (MoDNR 2019a), pH (standard units) (MoDNR 2018c), and discharge (cfs) (MoDNR 2017). Turbidity (NTU) (MoDNR 2018b) samples were collected in the field and kept on ice to be measured in the WQMS biology laboratory. All other samples were kept on ice and transported to the Chemical Analysis Section (**CAS**) of ESP in Jefferson City, Missouri. Physicochemical values were compared to Missouri Water Quality Standards (MoDNR 2019d); nutrients and turbidity were compared to the 25^{th} percentile of ecoregion IX as designated by the Environmental Protection Agency (**EPA**) (USEPA 2000). Nutrient criteria thresholds for Ecoregion IX Central Irregular Plains are 0.23 mg L^{-1} nitrite + nitrate as nitrogen, 0.712 mg L^{-1} total nitrogen, 0.0925 mg L^{-1} total phosphorus, and 15.5 NTU turbidity (USEPA 2000).

2.3 Bioassessment

West Fork Locust Creek was classified as a glide/pool stream where samples were collected from the following three habitats: non-flowing water over depositional substrate (**NF**), large woody debris (**SG**), and rootmat substrate (**RM**) in accordance with the *Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure* (**SMSBPP**) (MoDNR 2019c). Habitat samples were subsampled under 10 times magnification, and macroinvertebrate specimens were identified to specific taxonomic levels (MoDNR 2016d) in the laboratory.

Macroinvertebrate Stream Condition Index (**MSCI**) scores of WFL were calculated based on benthic macroinvertebrate subsamples. MSCI scores were determined based on biological criteria values calculated using biological reference stream sample data within the Central Plains/Grand/Chariton EDU (MoDNR 2019c). The MSCI is based on four biological metrics: taxonomic richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera taxonomic richness (**EPTT**); biotic index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score ranging between 16 and 20 is considered “fully supporting,” between 10 and 14 is “partially supporting,” and between 4 and 8 is “non-supporting” of the

protection of warm-water habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2019d). Data were compared within rather than across seasons for the sampling periods in the fall 2016 and spring 2017.

2.4 Quality Assurance/Quality Control (QA/QC) of Bioassessment Data

2.4.1 Data Collection

Data were collected following guidelines in *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019b).

2.4.2 Meter Calibration

Field meters necessary for the collection of temperature, turbidity, dissolved oxygen, pH, specific conductance, and discharge were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016a).

2.4.3 Macroinvertebrate Subsampling

Macroinvertebrates from collected samples were checked for accuracy using methods in the SMSBPP (MoDNR 2019c).

2.4.4 Macroinvertebrate Data Entry

Macroinvertebrate data were entered into the WQMS macroinvertebrate database in accordance with *Quality Control Procedures for Data Processing* (MoDNR2016b).

3.0 Bioassessment Results

3.1 Stream Habitat

Habitat measures indicated WFL stations were all “supporting” of aquatic life (Figure 2). The least comparable station to the reference stream of Spring Creek was WFL8, where the total score was 76 percent of the reference score (Table 2). Habitat disparities at WFL8 could be attributed to low bank vegetative protection and narrow riparian zone widths. Remaining stations at WFL were at least 90 percent similar to the reference stream, although every station lacked high-quality vegetative protection and had high sediment deposition.

Table 2. Habitat assessment of West Fork Locust Creek (WFL) stations, Sullivan County, Missouri, during the fall of 2016.

	Station					
Parameter	WFL8	WFL7	WFL6	WFL5	WFL2	Reference
Epifaunal substrate cover	1	6	6	3	4	3
Pool substrate characterization	12	18	12	12	13	14
Pool variability	8	17	17	10	14	4
Sediment deposition	0	3	2	1	2	1
Channel flow status	8	8	13	9	14	7
Channel alteration	19	19	14	17	19	20
Channel sinuosity	7	8	7	7	8	7
Bank stability	16	8	17	20	11	19
Vegetative protection	5	4	2	5	8	10
Riparian vegetative zone width	3	4	4	19	11	19
Total score	79	95	94	103	104	104
(Percent of Reference)	(76%)	(91%)	(90%)	(99%)	(100%)	(N/A)

Notes: Values in parentheses are percentages of the reference habitat score. WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge. The reference stream was Spring Creek, Adair County, Missouri.

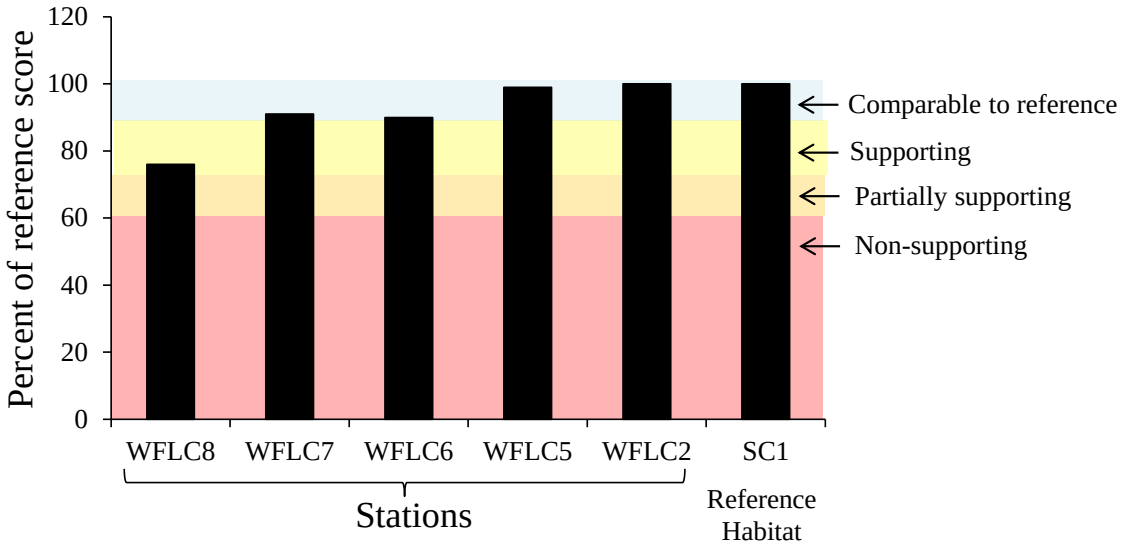

Figure 2. Stream habitat assessment comparison among West Fork Locust Creek (WFL) study stations, Sullivan County, and the reference station in Spring Creek (SC1), Sullivan County, Missouri, during the fall of 2016.

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge, SC1 = Spring Creek station.

3.2 Physicochemical Analysis

Fall season West Fork Locust Creek physicochemistry indicated nutrient levels and turbidity present among some WFL stations were higher than thresholds for EPA nutrient criteria (Table 3). Flow appeared to be typical of fall levels in the area, but heavy rains preceded the sampling period (Figure 3). The nutrient measures of total nitrogen, nitrate + nitrite as nitrogen, total nitrogen, and total phosphorus were above EPA recommended levels for at least one of these parameters at WFL2, WFL5, WFL7, and WFL8 (Figure 4). Stations WFL2 and WFL5 also exceeded EPA recommended levels for turbidity. Temperatures were warm (highest at WFL6, 22.1C), but dissolved oxygen remained at acceptable levels (8.32 mg L^{-1} – 9.32 mg L^{-1}). Stream pH was slightly basic among all stations (8.1 – 8.2).

Table 3. Physicochemical and nutrient data in West Fork Locust Creek (WFL) study stations, Sullivan County, Missouri, during the fall 2016.

	Station				
Parameter	WFL8	WFL7	WFL6	WFL5	WFL2
Ammonia (mg L^{-1})	0.079	0.15	0.10	0.097	0.10
Calcium (mg L^{-1})	51.1	54.7	53.9	52.7	46.6
Chloride (mg L^{-1})	10.8	10.4	8.00	8.67	9.07
Dissolved oxygen (mg L^{-1})	9.30	9.32	8.32	8.98	8.46
Flow (cfs)	2.1	2.6	8.9	7.7	14.4
Hardness (mg L^{-1})	179	190	187	184	162
Magnesium (mg L^{-1})	12.6	13.0	12.8	12.7	11.1
pH	8.2	8.1	8.1	8.2	8.2
Specific conductivity (µS cm^{-1})	373	414	394	386	361
Sulfate (mg L^{-1})	34.7	36.9	33.4	31.8	28.6
Temperature (°C)	13.9	15.6	22.1	17.8	17.8
Total Suspended Solids (mg L^{-1})	5.00	5.00	16.0	17.0	31.0
Turbidity (NTU)	6.34	6.11	13.4	**15.7**	**31.2**
Total Nitrogen (mg L^{-1})	0.70	0.62	0.62	**0.80**	**1.14**
Nitrate + Nitrite as N (mg L^{-1})	**0.26**	0.20	0.20	**0.27**	**0.47**
Total Phosphorus (mg L^{-1})	**0.098**	**0.094**	0.088	**0.10**	**0.12**

Notes: Values in bold are levels in exceedance of the 25th percentile as recommended by the EPA in 2000, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

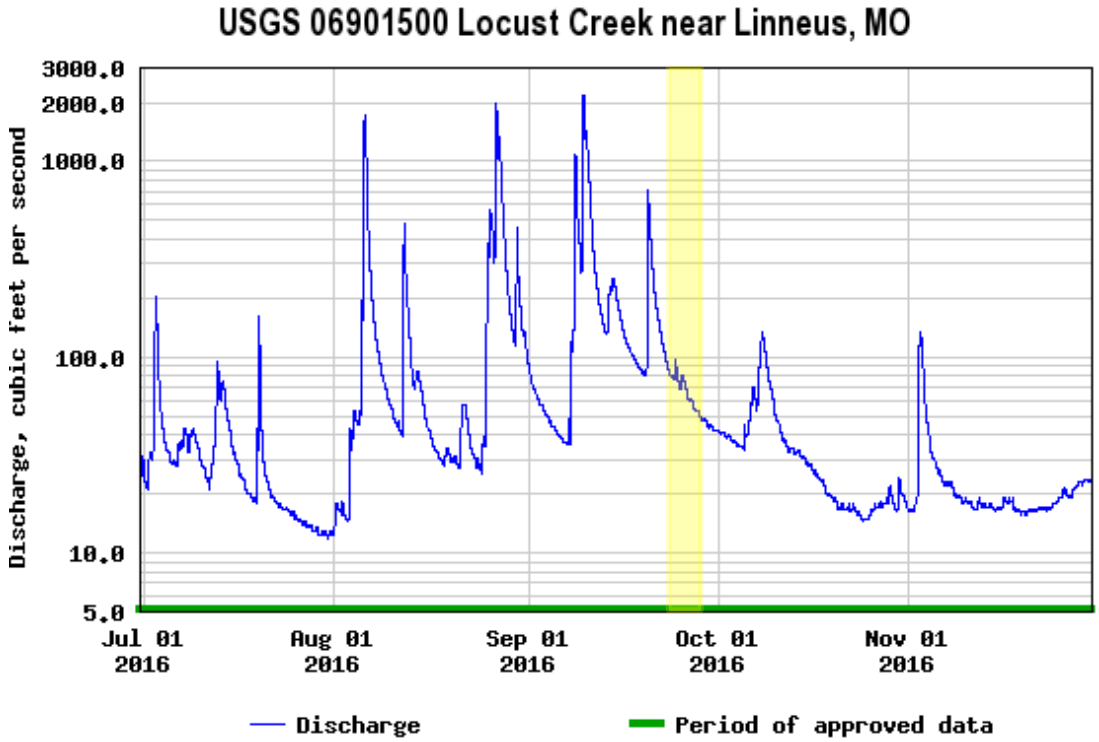

Figure 3. Hydrograph of Locust Creek, Linn County, Missouri, during late summer to mid fall 2016.

Notes: Locust Creek receives West Fork Locust Creek and is located approximately 10.5 miles downstream of the most downstream WFL station. Sampling in the fall occurred on September 26-27, 2016, as indicated by the highlighted area.

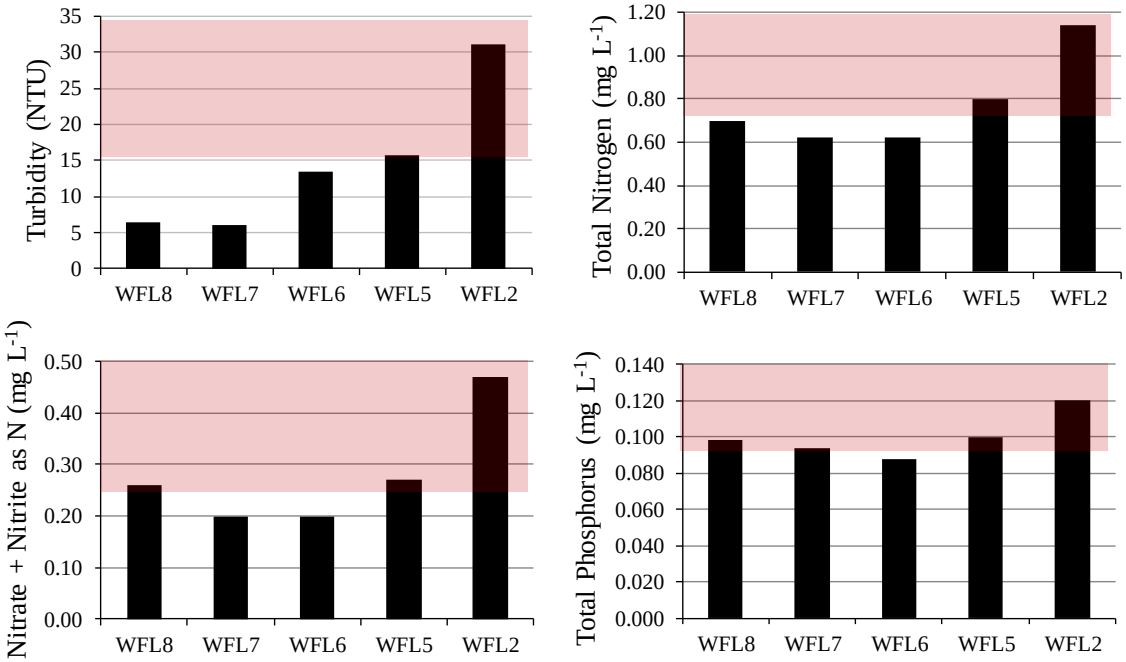

Figure 4. Turbidity and nutrient levels in West Fork Locust Creek (WFL) study stations, Sullivan County, Missouri, during the fall 2016.
Notes: Red shading indicates where values exceeded the EPA ecoregion 25th percentile, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

In the spring, nutrients at all West Fork Locust Creek stations exceeded EPA recommended nutrient criteria levels (Table 4). Other parameters including pH, turbidity, and dissolved oxygen were higher than in the fall. Turbidity was as much as three times higher in the spring than in the fall. Total nitrogen and nitrate + nitrite as nitrogen were around two times higher in the spring than in the fall season (Figure 5). Flow was higher in mid-March through the spring season in comparison to the fall season as seen in the gage located downstream at Locust Creek (Figure 6).

Table 4. Physicochemical and nutrient data in West Fork Locust Creek (WFL) study stations, Sullivan County, Missouri, during the spring 2017.

	Station				
Parameter	WFL8	WFL7	WFL6	WFL5	WFL2
Ammonia (mg L^{-1})	0.22	0.20	0.17	0.17 *	0.29
Calcium (mg L^{-1})	50.6	47.3	48.4	48.1	44.0
Chloride (mg L^{-1})	11.2	13.7	11.4	11.1	11.0
Dissolved oxygen (mg L^{-1})	10.78	10.77	10.67	10.57	10.31
Flow (cfs)	19.9	24.3	42.7	38.8	73.6
Hardness (mg L^{-1})	176	165	169	168	154
Magnesium (mg L^{-1})	12.1	11.3	11.7	11.7	10.7
pH	7.9	7.9	7.8	7.9	8.0
Specific conductivity (µS cm^{-1})	396	385	369	366	348
Sulfate (mg L^{-1})	44.0	41.3	38.9	36.4	36.5
Temperature (°C)	9.7	9.8	10.5	11.0	11.1
Total suspended solids (mg L^{-1})	58.0	83.0	96.0	95.0	85.0
Turbidity (NTU)	**49**	**77**	**80**	**79**	**99**
Total nitrogen (mg L^{-1})	**2.57**	**2.65**	**2.13**	**2.13***	**2.75**
Nitrate +Nitrite as N (mg L^{-1})	**1.57**	**1.59**	**1.16**	**1.11***	**1.47**
Total phosphorus (mg L^{-1})	**0.16**	**0.19**	**0.18**	**0.16***	**0.20**

Notes: Values in bold are levels in exceedance of the 25th percentile as recommended by the EPA in 2000, * indicates improper preservation of sample, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

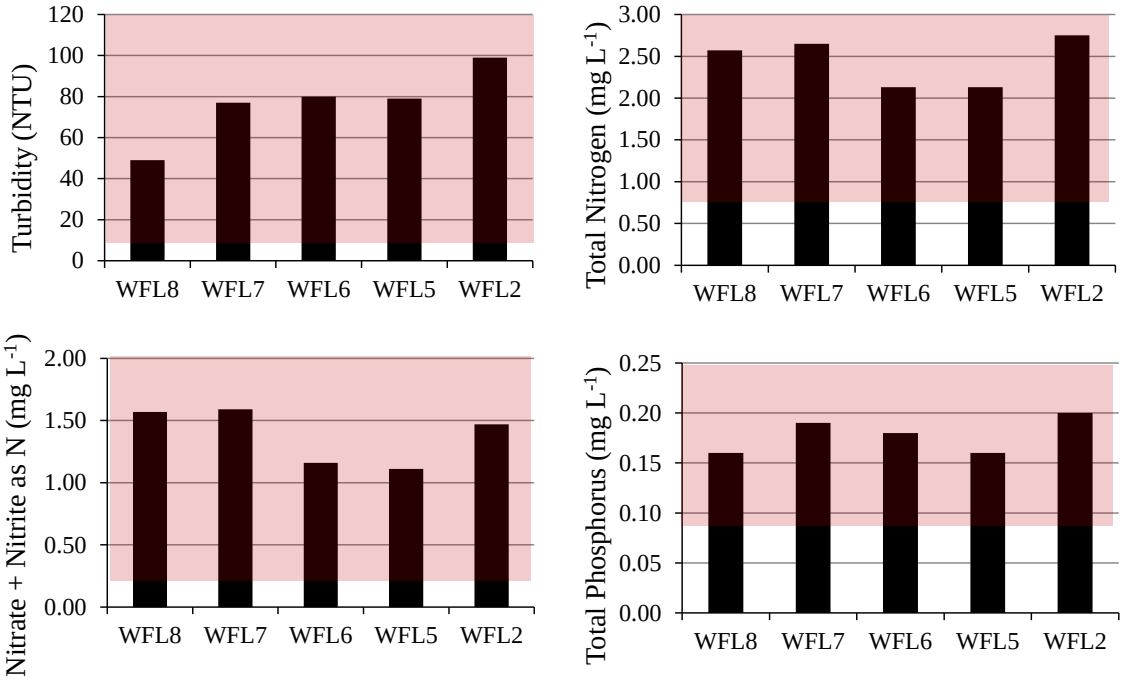

Figure 5. West Fork Locust Creek physical parameters in exceedance of recommended EPA levels in the spring 2017.

Notes: Red shading indicates where values exceeded the 2000 EPA ecoregion 25th percentile. WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

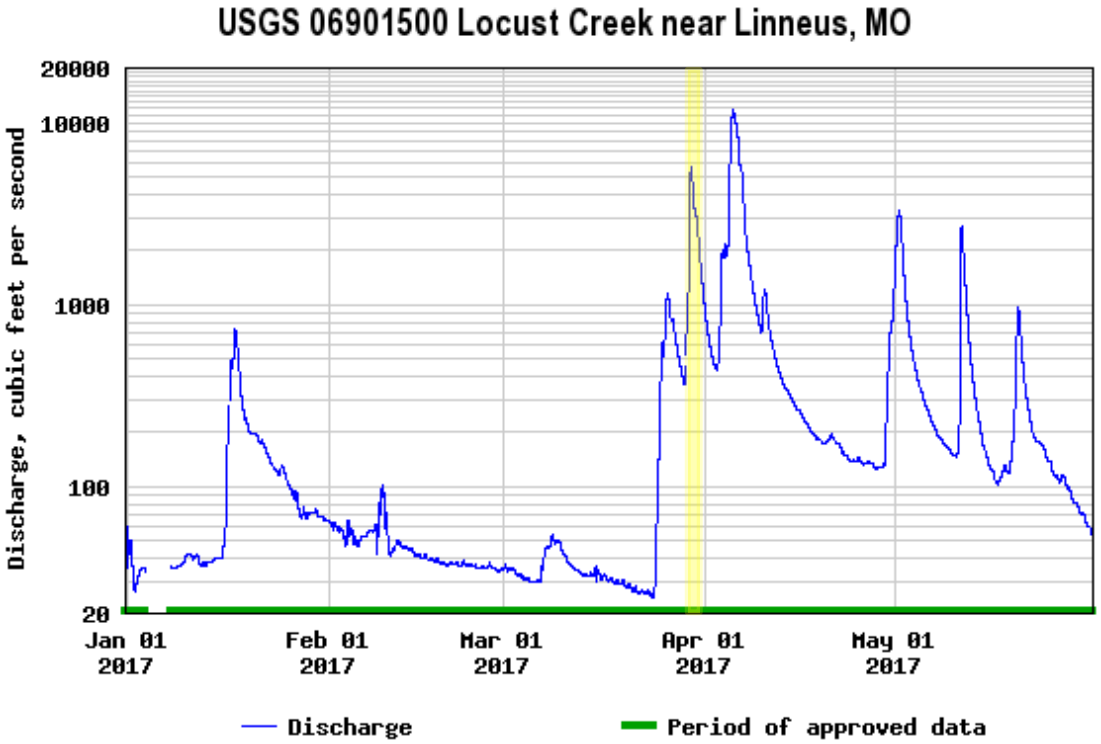

Figure 6. Spring hydrograph of Locust Creek, Linn County, Missouri, during late winter to spring 2017.

Notes: Locust Creek receives West Fork Locust Creek and is located approximately 10.5 miles downstream of the most downstream WFL station. Sampling in the spring occurred on March 28, 2017, as indicated by the highlighted area.

3.3 Biological Assessment

3.3.1 Macroinvertebrate Community Composition

Fall macroinvertebrate communities at West Fork Locust Creek stations were dominated by Diptera (Figure 7), but at least 30 percent of any station included the pollution-sensitive orders of Ephemeroptera and Trichoptera (Table 5). Plecoptera were entirely absent from WFL stations. Among the five most common genera, WFL stations were abundant in Diptera (five genera), Ephemeroptera (three genera), Odonata (one genus), Trichoptera (one genus) and Tubificida (one genus) specimens (Table 6). These common genera included several pollution-sensitive taxa (BI < 5). For instance *Pseudocloeon* (BI = 4) was common at WFL7, and *Heptagenia* (BI = 2.8) was collected from WFL8, WFL7, and WFL5. The station WFL7 also had the highest percentage of the macroinvertebrate community (27 percent) with a biotic index value less than five (Table 7).

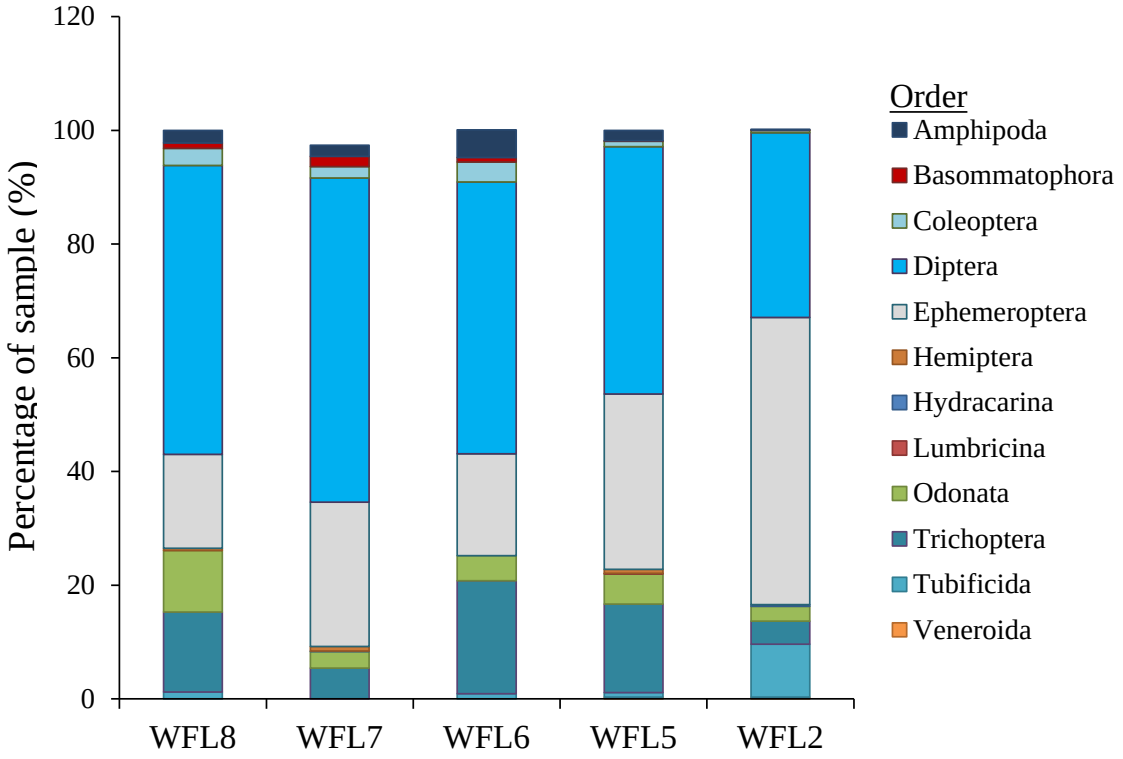

Figure 7. Order-level composition of samples at West Fork Locust Creek (WFL) stations, Sullivan County, Missouri, during the fall 2016.

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 5. Percentages of Ephemeroptera, Plecoptera, and Trichoptera taxa within West Fork Locust Creek, Sullivan County, Missouri during the fall 2016 and spring 2017 sampling seasons.

		Station				
Order (%)	Season	WFL8	WFL7	WFL6	WFL5	WFL2
Ephemeroptera	F	16.5	25.4	17.9	30.8	50.5
	S	4.2	7.5	4.5	8	15.3
Plecoptera	F	0	0	0	0	0
	S	0	0	0	0.001	0
Trichoptera	F	14.1	5.4	19.9	15.6	4.1
	S	0.4	0.4	0	0.5	0.4
Total	F	30.6	30.8	37.8	46.4	54.6
	S	4.6	7.9	4.5	8.501	15.7

Notes: F = fall 2016, S = spring 2017, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 6. Five most common taxa (percentage of sample) in West Fork Locust Creek, Sullivan County, Missouri during the fall 2016.

	Station				
Genus	WFL8	WFL7	WFL6	WFL5	WFL2
Branchiura sowerbyi	-	-	-	-	5.99
Calopteryx	7.97	-	-	-	-
Caenis latipennis	-	-	5.92	9.31	46.5
Pseudocloeon	-	4.49	-	-	-
Heptagenia	7.17	13.69	-	6.39	-
Cheumatopsyche	12.55	-	15.33	8.75	-
Dicrotendipes	-	-	-	-	4.97
Polypedilum illinoense grp.	11.16	15.88	5.01	14.17	4.59
Stempellinella	-	5.06	-	-	
Tanytarsus	9.76	11.39	9.71	7.22	6.62
Simulium	-	-	5.46	-	-

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 7. Cumulative percentage of communities at West Fork Locust Creek (WFL) belonging to biotic index (BI) categories in comparison to the entire Central Plains/Grand/Chariton Ecological Drainage Unit (EDU) during the fall 2016.

	Station					
BI range	WFL8	WFL7	WFL6	WFL5	WFL2	Fall EDU
< 1.0	0	0	0	0	0	0
1.0 – 1.9	0	0	0	0	2	0
2.0 – 2.9	8	16	5	9	2	7
3.0 – 3.9	9	16	8	11	3	11
4.0 – 4.9	18	27	17	24	8	16
5.0 – 5.9	23	36	23	30	11	22
6.0 – 6.9	56	62	63	55	26	44
7.0 – 7.9	71	73	86	76	81	81
8.0 – 8.9	85	78	93	81	92	90
9.0 – 10	100	100	100	100	100	100

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

The spring macroinvertebrate community of West Fork Locust Creek was dominated by the order Diptera (Figure 8), and less than 16 percent of any station belonged to the pollution-sensitive orders of Ephemeroptera, Plecoptera, and Trichoptera (Table 5). Of the Plecoptera, only a single specimen of *Taeniopteryx* was present at WFL5. More than 75 percent of the macroinvertebrate communities at WFL stations were members within Diptera. Order-level evenness was low, and this was also apparent at the genus level where the chironomids *Cricotopus/Orthocladius* and *Tanytarsus* were among the most common individuals (Table 8). Similar to the fall season, WFL7 had the highest pollution-sensitive macroinvertebrate community (23 percent) with a BI < 5.0 in spring season (Table 9).

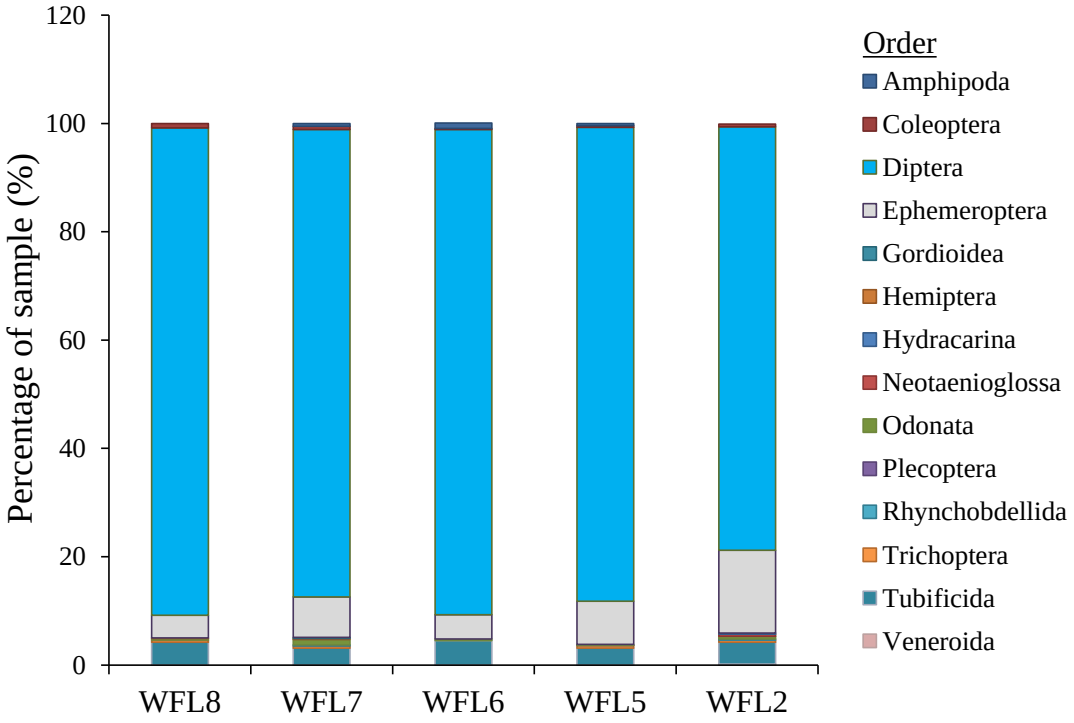

Figure 8. Order-level composition of samples at West Fork Locust Creek (WFL) stations, Sullivan County, Missouri, during the spring 2017.
Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 8. Five most common taxa (percentage of sample) in West Fork Locust Creek, Sullivan County, Missouri during the spring 2017.

	Station				
Genus	WFL8	WFL7	WFL6	WFL5	WFL2
Caenis latipennis	-		-	-	10.65
Heptagenia	-	5.36	-	-	-
Ablabesmyia	-	-	-	-	3.79
Cricotopus bicinctus	7.53	-	6.77	4.30	-
Cricotopus/Orthocladius	20.78	33.10	38.61	28.16	16.77
Polypedilum illinoense grp.	5.44	6.67	6.60	3.84	8.81
Tanytarsus	29.85	11.79	14.36	24.88	28.15
Simulium	5.72	15.71	4.62	5.80	-

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 9. Cumulative percentage of communities at West Fork Locust Creek (WFL) belonging to biotic index (BI) categories in comparison to the entire Central Plains/Grand/Chariton Ecological Drainage Unit (EDU) during the spring 2017.

	Station					
BI range	WFL8	WFL7	WFL6	WFL5	WFL2	Spring EDU
< 1.0	0	1	0	1	0	1
1.0 – 1.9	0	1	0	2	0	1
2.0 – 2.9	2	6	1	3	1	1
3.0 – 3.9	2	7	2	4	3	4
4.0 – 4.9	9	23	8	13	6	10
5.0 – 5.9	10	25	9	15	7	14
6.0 – 6.9	70	76	69	77	62	48
7.0 – 7.9	76	81	77	84	79	78
8.0 – 8.9	86	88	86	91	85	85
9.0 – 10	100	100	100	100	100	100

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

3.3.2 Macroinvertebrate Stream Condition Index (MSCI) Scores

During the fall season, every WFL station attained fully supporting MSCI scores of 16 or higher. Scores of at least 16 are interpreted as stream reaches with macroinvertebrate communities that fully support the beneficial use designation (Tables 10 and 11). Among individual metrics, richness (TR and EPTT) and evenness (SDI) were highest at WFL5 (Figure 9). The lower MSCI score of 16 occurred at the most downstream WFL2 station and was due to evenness and pollution-tolerant taxonomic metrics (Table 10). When the current 2016 study is compared to the previous study conducted in 2007, at least three of the five stations showed an improvement in metric values. The majority of improvements occurred at mid-reach stations WFL5, WFL6, and WFL7 (Figure 10).

Table 10. Metric scores for West Fork Locust Creek, Sullivan County, Missouri, during the fall of 2016.

Station	TR	EPTT	SDI	BI	MSCI score	Interpretation
WFL8	57 (5)	11 (5)	3.25 (5)	6.8 (5)	20	Fully supporting
WFL7	68 (5)	13 (5)	3.22 (5)	6.4 (5)	20	Fully supporting
WFL6	64 (5)	14 (5)	3.37 (5)	6.5 (5)	20	Fully supporting
WFL5	75 (5)	19 (5)	3.38 (5)	6.6 (5)	20	Fully supporting
WFL2	57 (5)	13 (5)	2.42 (3)	7.2 (3)	16	Fully supporting

Notes: TR = taxa richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxa richness, SDI = Shannon Diversity Index, BI = Biotic Index, MSCI = Macroinvertebrate Stream Condition Index, Values in () are scores according to threshold values in Table 11, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 11. Metric score calculation boundaries at West Fork Locust Creek, Sullivan County, Missouri, during the fall 2016.

Metric score	TR	EPTT	SDI	BI
5	x >51	x >9	x >2.69	x <7.2
3	25≤ x ≤51	5≤ x ≤9	1.35≤ x ≤2.69	8.6≥ x ≥7.2
1	x <25	x <5	x <1.35	x >8.6

Notes: TR = taxa richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera richness, SDI = Shannon Diversity Index, BI = Biotic Index.

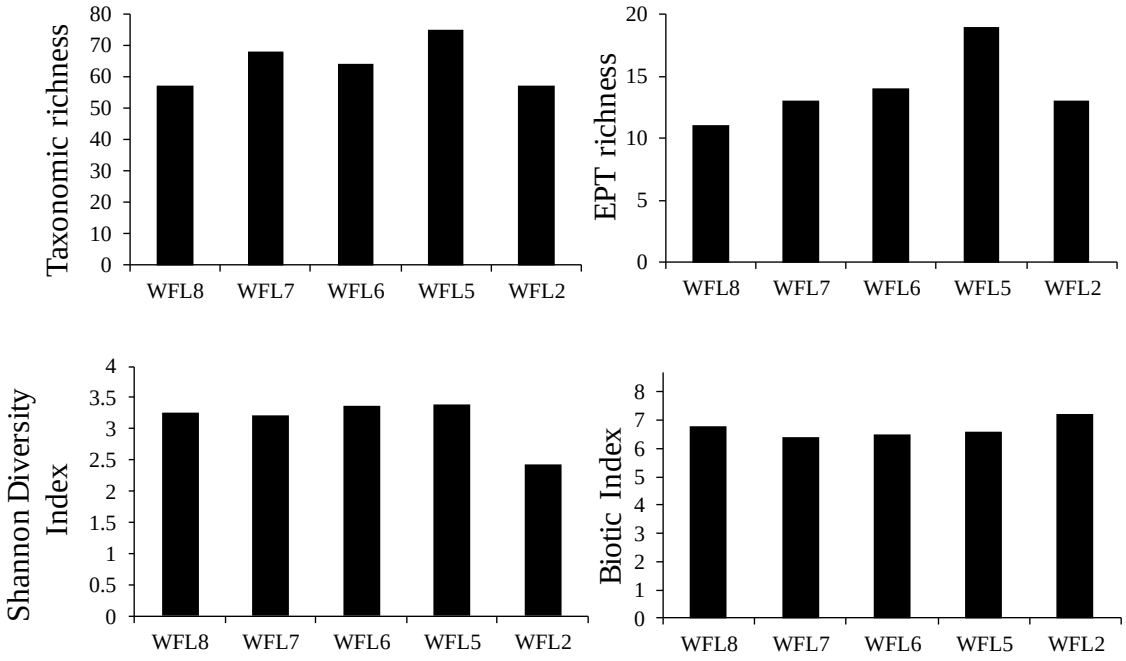

Figure 9. Macroinvertebrate Stream Condition Index (MSCI) metrics at West Fork Locust Creek (WFL), Sullivan County, Missouri, during the fall 2016.
Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

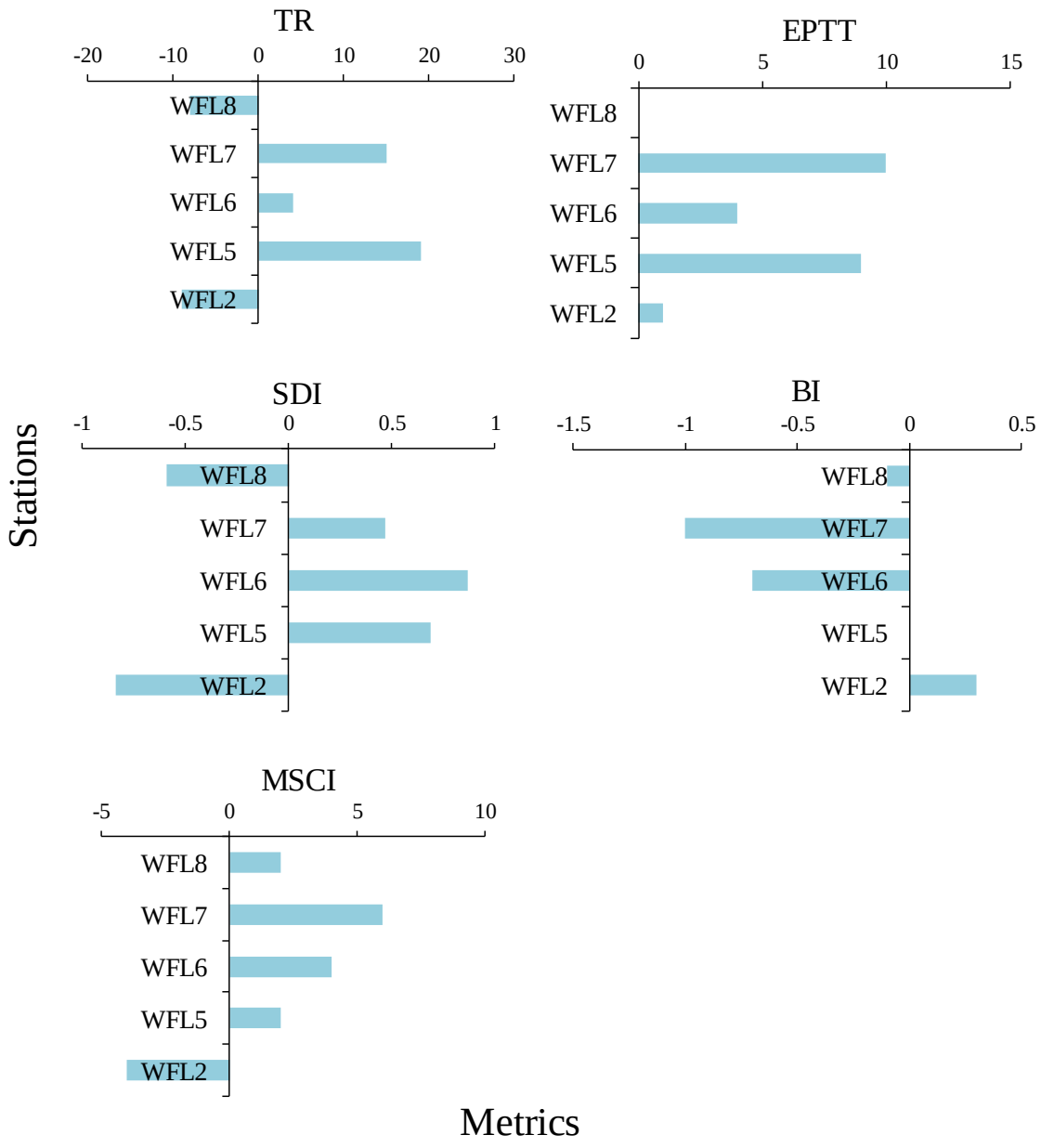

Figure 10. Difference between metric scores during the 2007/2008 study and the 2016/2017 study at West Fork Locust Creek, Sullivan County, Missouri, during the fall.
Notes: TR = taxa richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxa richness, SDI = Shannon Diversity Index, BI = Biotic Index, MSCI = Macroinvertebrate Stream Condition Index, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge. Positive values indicate improvement in the current study in comparison to the previous study except for the BI where negative values indicate improvement.

Four of the five WFL stations had fully supporting MSCI scores in spring (Tables 12 and 13). Due to laboratory error, however, part of the nonflow portion of the WFL6 sample was lost. This habitat failed to meet the target number, which may have resulted in lower metric values. The most downstream stations WFL5 and WFL2 had fully supporting metric scores except for the BI at WFL2 (Figure 11). At least two WFL stations improved on every metric; and four WFL stations had a higher MSCI score when compared to samples collected in the 2008 study (Figure 12). No WFL stations had lower MSCI scores in the 2016/2017 bioassessment study in comparison to the 2007/2008 bioassessment study.

Table 12. Metric scores for West Fork Locust Creek, Sullivan County, Missouri, during the spring of 2017.

Station	TR	EPTT	SDI	BI	MSCI score	Interpretation
WFL8	52 (5)	8 (3)	2.61 (5)	7.0 (5)	18	Fully supporting
WFL7	58 (5)	6 (3)	2.55 (5)	6.5 (5)	18	Fully supporting
WFL6	47 (3)	5 (3)	2.45 (3)	7.0 (5)	14	Partially supporting
WFL5	64 (5)	11 (5)	2.68 (5)	6.7 (5)	20	Fully supporting
WFL2	56 (5)	10 (5)	2.75 (5)	7.1 (3)	18	Fully supporting

Notes: TR = taxa richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxa richness, SDI = ShannonDiversity Index, BI = Biotic Index, MSCI = Macroinvertebrate Stream Condition Index, Values in () are scores according to threshold values in Table 13, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

Table 13. Metric score calculation boundaries at West Fork Locust Creek, Sullivan County, Missouri, during the spring 2017.

Metric score	TR	EPTT	SDI	BI
5	x >50	x >8	x >2.51	x <7.0
3	25≥ x ≥50	4≥ x ≥8	1.25≥ x ≥2.51	7.0≤ x ≤8.7
1	x <25	x <4	x <1.25	x >8.7

Notes: TR = taxa richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxa richness, SDI = Shannon Diversity Index, BI = Biotic Index.

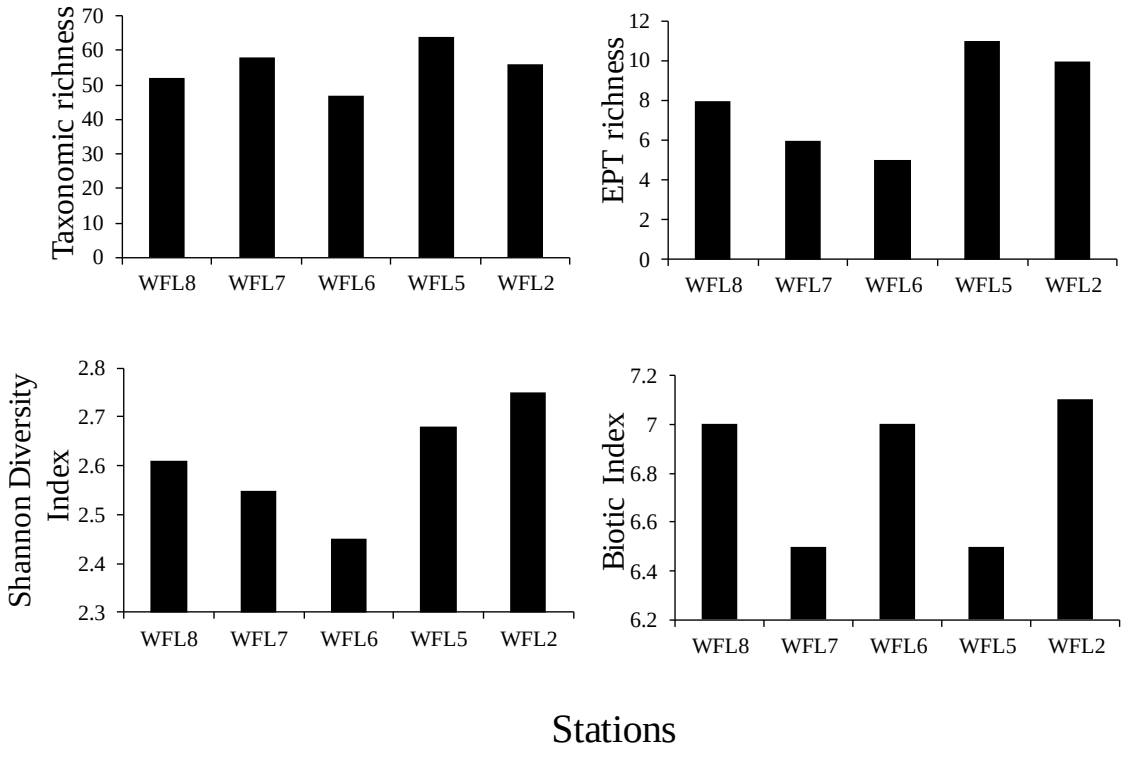

Figure 11. Macroinvertebrate Stream Condition Index (MSCI) metrics at West Fork Locust Creek (WFL), Sullivan County, Missouri during the spring 2017.
Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

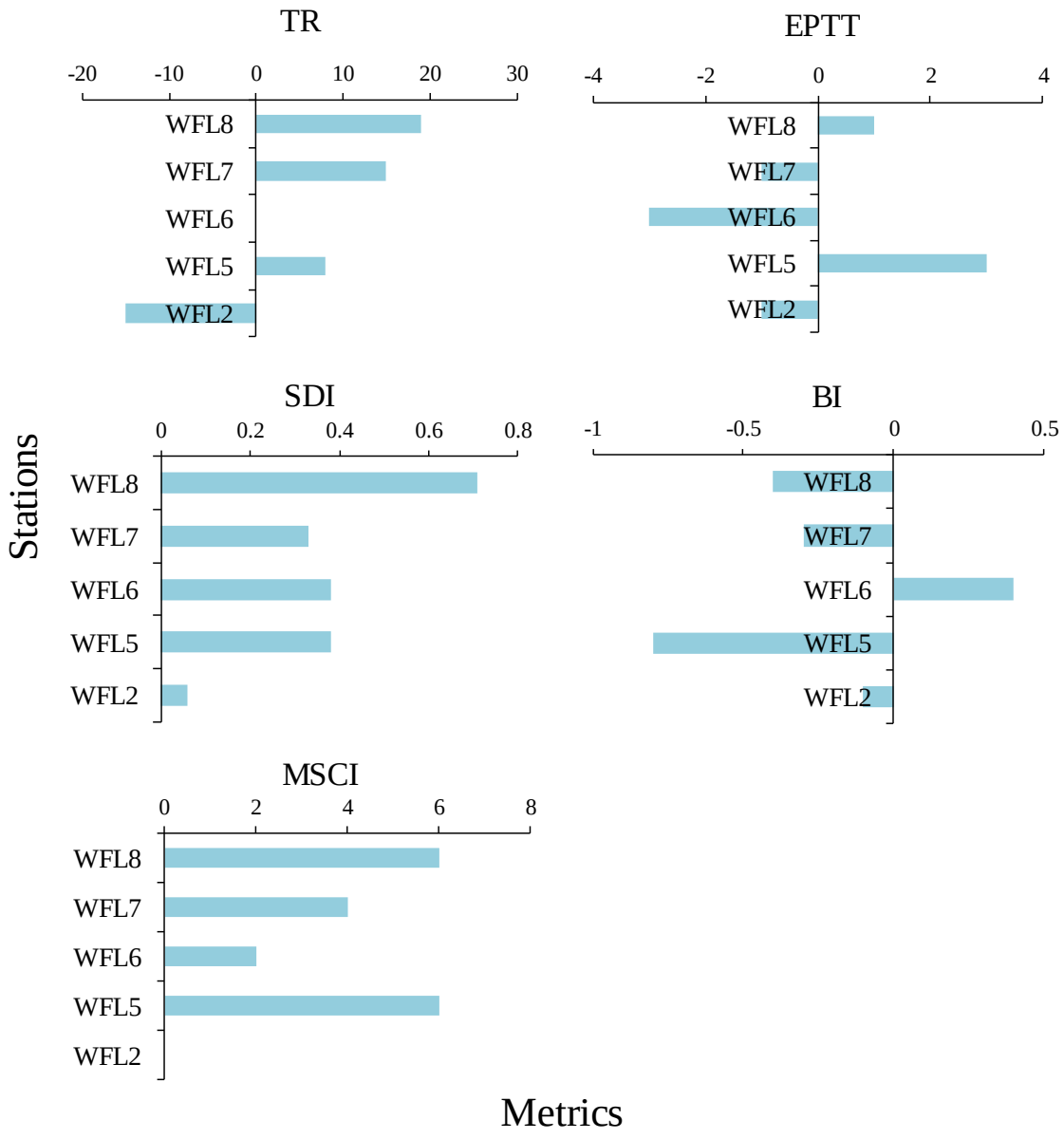

Figure 12. Difference between metric scores during the 2007/2008 study and the 2016/2017 study at West Fork Locust Creek, Sullivan County, Missouri, during the spring.

Notes: TR = taxa richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxa richness, SDI = Shannon's Diversity Index, BI = Biotic Index, MSCI = Macroinvertebrate Stream Condition Index, WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge. Positive values indicate improvement in the current study in comparison to the previous study except for the BI where negative values indicate improvement.

4.0 Discussion

4.1 Stream Habitat

Stream habitat scores were "supporting" among all WFL stations and WFL2, WFL5, WFL6, and WFL7 were "comparable to the reference," indicating adequate physical heterogeneity was present to support the aquatic macroinvertebrate community. Stations WFL2, WFL5, and WFL6 were the most downstream; therefore, greater flow may be a reason for improved habitat (WFL8 flow = 2.1cfs, WFL2 flow = 14.4 cfs). Higher flow creates more habitat and makes resources more accessible to support and sustain macroinvertebrate populations. In relation to flow, pool variability was also high among stations WFL7 and downstream, and this variable also relates to flow levels as high variability is only possible when water levels are higher. Flow is one of the four most important variables limiting macroinvertebrate communities (Hynes 1970).

4.2 Physicochemical Analysis

The fall physicochemistry of West Fork Locust Creek had higher nutrient concentrations and turbidity readings than levels recommended by the EPA (USEPA 2000). High nutrients in agricultural landscapes are expected due to fertilization and lower forest cover (Moore and Palmer 2005). Nearly all WFL stations had a surrounding watershed of soybean and corn crops. Areas with higher riparian vegetative zone width would be expected to have lower nutrient levels, but these two variables appeared to be unrelated in the fall 2016 sampling season. If nutrient sources upstream or in the surrounding landscape are great enough, then localized variables like riparian zone width can be overwhelmed (Roth et al. 1996). Flow levels would also affect nutrient runoff into the stream. However, fall water flow was very low (highest discharge = 14.4 cfs), suggesting nutrient runoff should have been lower. Turbidity levels were also in exceedance of recommended EPA levels. Increased turbidity in streams is related to increased sedimentation and is usually a result of channel alteration, vegetation removal, high traffic due to vehicles or livestock, or severe weather. High turbidity can impede macroinvertebrate respiration, and suspended particles in the water column favor silt-adapted taxa (Henley et al. 2000) while impeding feeding strategies for predators dependent on visuals cues (Kefford et al. 2010). High sedimentation will also decrease critical interstitial habitat for benthic macroinvertebrates (Wagenhoff et al. 2012). Although both sedimentation and nutrients can be stressors in agricultural settings, sedimentation is a greater threat to macroinvertebrate communities (Wagenhoff et al. 2012). In general, the macroinvertebrate community of West Fork Locust Creek included those favoring more sediment-tolerant taxa such as Tubificidae. However, such taxonomic observations were unsurprising for a glide/pool northern Missouri stream (Zweig and Rabeni 2001).

Although nutrients and turbidity were high in WFL stations, flow levels were also suspect due to extremely low fall levels. As previously mentioned, flow is a critical variable inhibiting macroinvertebrates, which decreases both survival and diversity. Despite low fall flows, dissolved oxygen levels were close to saturation, and oxygen levels likely did not threaten survival of macroinvertebrates (Connolly et al. 2004). However, low flows

do constrict the resources available for macroinvertebrates while increasing competition due to restricted space.

Spring 2017 WFL physicochemistry included nutrient levels that were higher than those recommend by the EPA (USEPA 2000) at every station, with the highest total nitrogen and total phosphorus concentrations occurring at WFL2. Higher nutrients are expected in agricultural streams (Carpenter et al. 1998), and nutrients coupled with instream habitat help to interpret the macroinvertebrate community (Wang et al. 2007). Nutrient concentrations did not, however, consistently relate to individual biological metrics at WFL stations. In addition to potential agricultural fertilizers in the watershed, nine CAFOs are located within 2 miles upstream of station WFL8. Many of these are swine CAFOs, which have been documented as contributing considerable quantities of waste to waterways through runoff (Burkholder et al. 2007, Mallin and Cahoon 2003). Although nutrients were high in comparison to EPA recommendations, these parameters cannot definitively be linked to CAFOs because of the placement of sample sites. The CAFOs were present near the most upstream and most downstream stations, and other agricultural influences were present throughout the study reach, which makes it difficult to parse out individual relationships. A comparison to a stream with similar agricultural input without any CAFOs in the watershed would help to address specific influences from these animal operations. The highest nutrient concentrations were collected from WFL2 and were expected because it was the most downstream station sampled.

Turbidity was high and above EPA recommended levels at all stations in the spring. The macroinvertebrate community did not show any clear trends between taxa and turbidity levels, although *Caenis latipennis* (sprawling habit) did increase drastically at WFL5 and WFL2 (*C. latipennis* = 28 and 87 individuals, respectively) in comparison to the upstream stations WFL8, WFL7, and WFL6 (*C. latipennis* = 1, 2, and 4 individuals, respectively) potentially reflecting increasing turbidity. The mayfly *Caenis* can survive better in habitats with higher levels of fine sediments than other macroinvertebrates (Akamagwuna et al. 2019). Fine sediments interfere with macroinvertebrate respiration by clogging gills (Lemly 1982), and *Caenis* have operculate gill covers to prevent clogging on gills. Aside from nutrients and turbidity, pH remained only slightly basic, and dissolved oxygen levels approached saturation, indicating the strongest physicochemical drivers were likely nutrient and turbidity related.

Insecticides are a general concern in agricultural streams like West Fork Locust Creek, and the shredder FFG may be indicative of the presence of insecticides (Liess and Schultz 1999). Insecticides and toxicity bioassays were not conducted in this study, but shredders made up a large component of the FFGs at all stations except WFL2 in the fall season (Figure 13). Given the higher percentage of shredders among all WFL stations, especially in the spring 2017, insecticides do not appear to pose a current threat to the macroinvertebrate community. The near absence of shredders at WFL2 in the fall was possibly a result of lower flow and the lack of woody debris necessary to support this FFG.

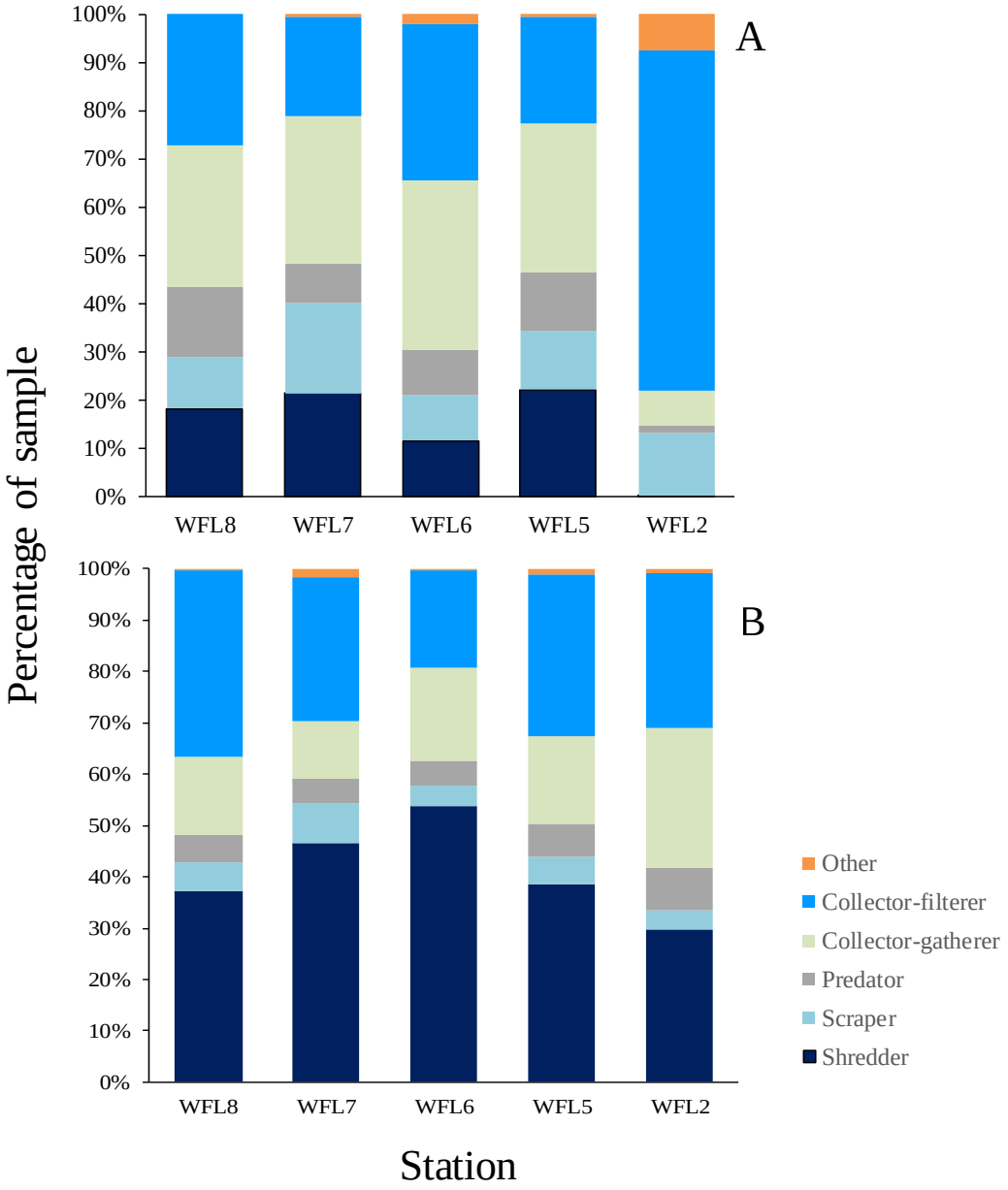

Figure 13. Functional feeding groups within samples from West Fork Locust Creek, Sullivan County, Missouri during the fall 2016 (A) and spring 2017 (B) seasons.
Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

4.3 Biological Assessment

4.3.1 Macroinvertebrate Community Composition

The macroinvertebrate community was not particularly taxonomically diverse, taxonomically even, or abundant in pollution-sensitive taxa. In the fall and spring seasons, most taxa were within the Diptera and Ephemeroptera orders and included nearly 50 percent pollution-tolerant taxa. The taxa within the EPTT metric made up about half of the total fall taxa and about 10 percent of the spring taxa. Because the MSCI scores did not indicate impairment (except for WFL6 during the spring), it was apparent northern prairie streams such as West Fork Locust Creek do not attain high diversity. Due to increased fine sediments and the flashiness of the stream during rain events, organisms with specialized adaptations to shifting substrates and variable flow are likely favored (Dodds et al. 2004).

Station WFL6 attained a partially supporting MSCI score in spring, but this may be attributed to a laboratory error in which a portion of the nonflow sample was lost. The nonflow habitat calculations were based on only 96 macroinvertebrate individuals rather than the targeted 300 individuals, which means that the taxa richness curve was unable to approach the asymptote. Further, because the remaining WFL stations had fully supporting MSCI scores, and because station WFL6 had an MSCI score of 20 during the previous season, it likely would have attained a similar MSCI score had this laboratory error not occurred.

Taxa richness (TR) and EPTT were highest at WFL5 in both sample seasons, possibly because of habitat quality. The total habitat score at WFL5 was especially high (99 percent of the reference), and several habitat parameters separated WFL5 from remaining stations. For instance, the WFL5 riparian zone width and channel stability scores were highest, and channel alteration was lowest among all stations. Habitat has previously explained nearly half of the variation in macroinvertebrate communities (Wang et al. 2007), and local habitat parameters have related well to biotic integrity (Lammert and Allan 1999), which makes habitat an important variable to consider in bioassessment studies. If habitat quality affects taxa richness, then TR should be lower where habitat scored poorly. Fall richness measures were low in TR and lowest in EPTT at WFL8. Although channel stability and channel alteration parameters scored well at WFL8, riparian zone width, epifaunal substrate cover, and sediment deposition habitat scores were lowest here in comparison to remaining stations. Overall, these factors suggest that habitat quality may only partially explain macroinvertebrate metrics in West Fork Locust Creek.

4.3.2 Macroinvertebrate Stream Condition Index (MSCI) Scores

With the exception of WFL6 in spring, all stations had fully supporting MSCI scores in both seasons. Drought and flood conditions were suspected of causing lower MSCI scores in upstream WFL stations during the 2007/2008 bioassessment study (MoDNR 2009); however, our study underwent similar weather conditions with different results, suggesting that normal variation and patchiness in the biota may have contributed to the

lower MSCI scores found previously (Lake 2000). Generally, station WFL2 (Class P) had lower TR, EPTT, and SDI and higher BI metric values than upstream stations (Class C) during the fall season, but this trend did not apply in the spring season. Further, higher metric values were calculated in the upstream portions of WFL stations where discharge was highly variable. These data suggest MSCI scores are not strictly dependent upon disturbance due to floods and drought because these events would be expected to more severely affect upstream sections of WFL. As mentioned previously, habitat parameters helped to explain trends found among fall metrics, which factored into MSCI scores. In the spring, floods may explain some lowered values in all metrics in comparison to the fall season. However, any floods are unlikely to induce long-term damage to the macroinvertebrate community because they induce pulse disturbances (Lake 2000), which have fairly rapid recoveries.

The biotic index (BI) metric related well to total nitrogen and total phosphorus levels during the fall 2016 season. As fall nutrient levels increased so did BI metric values (Figure 14). The BI is a measure of organic pollution tolerance in the maroinvertebrate community and may also respond to elevated nutrient concentrations. Nutrients are beneficial to macroinvertebrates at intermediate levels, but they are detrimental at excessive levels, especially when coupled with sedimentation effects (Matthaei et al. 2010, Smith et al. 1999). This nutrient relationship to BI values in the fall season did not extend into the spring 2017 season (Figure 15), suggesting that nutrient concentrations were not the primary driving force behind the taxa found in the WFL macroinvertebrate spring community.

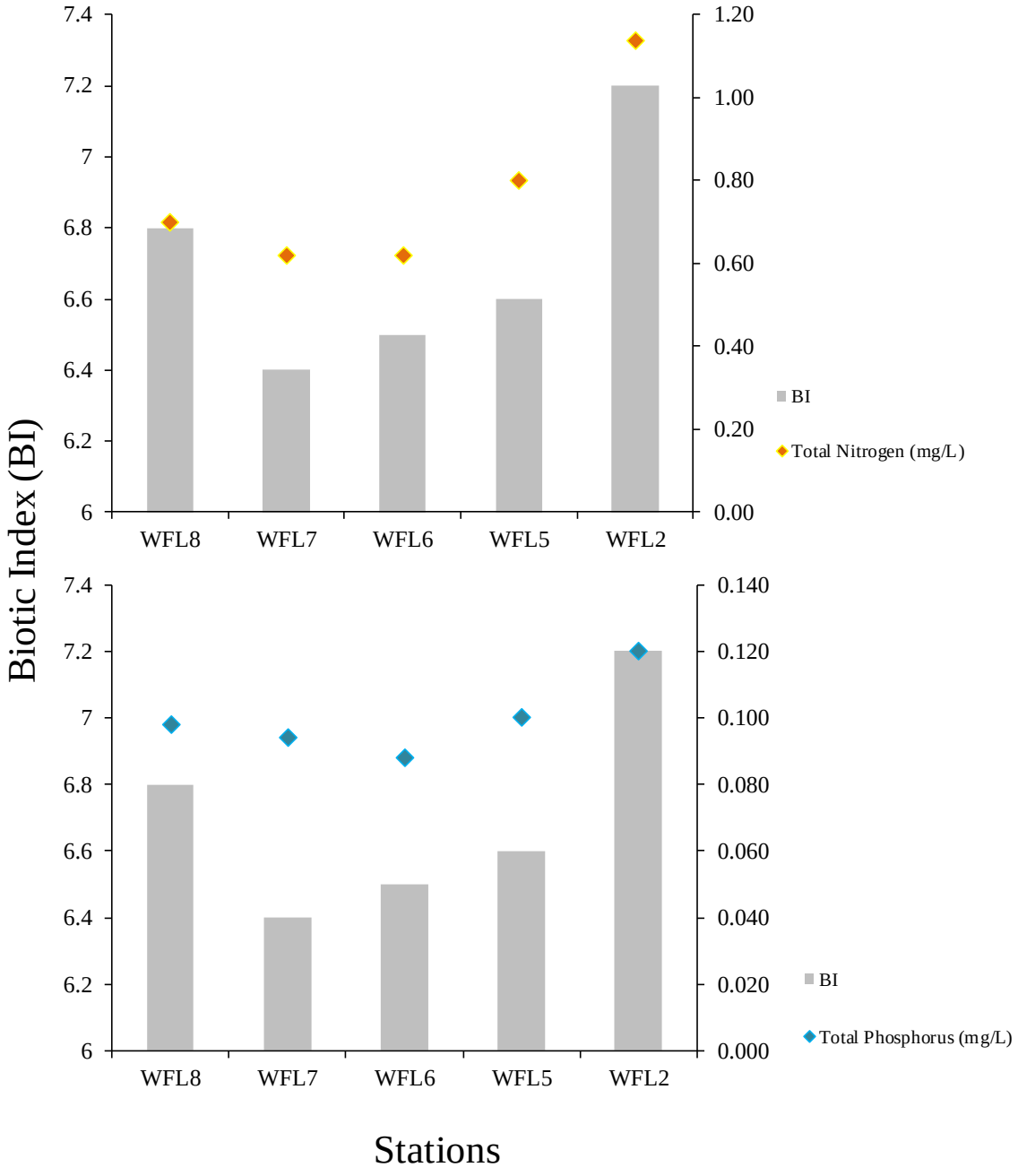

Figure 14. Relationship between biotic index and nutrients in West Fork Locust Creek, Sullivan County, Missouri during the fall 2016.

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

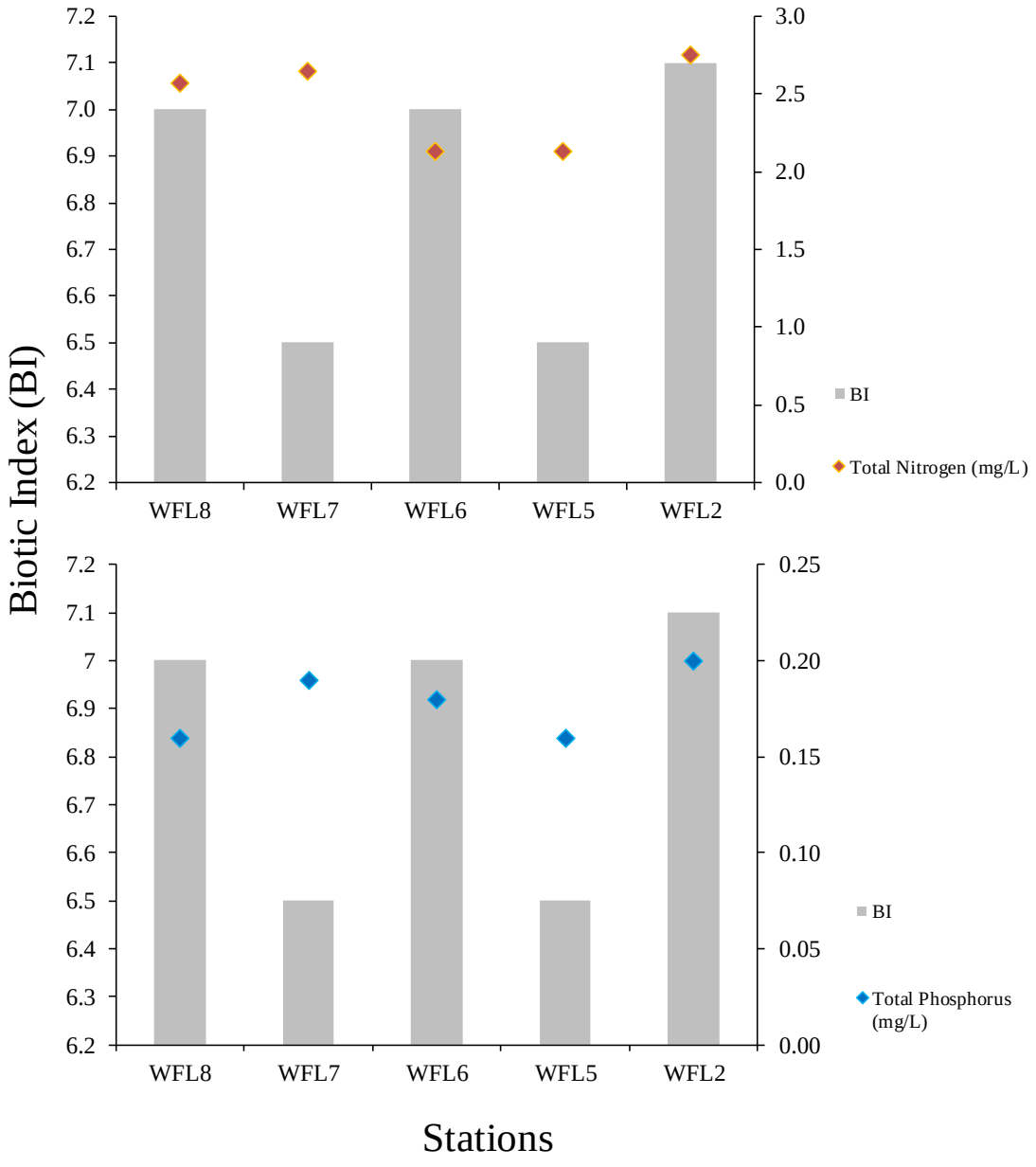

Figure 15. Relationship between biotic index and nutrients in West Fork Locust Creek, Sullivan County, Missouri during the spring 2017.

Notes: WFL8 = most upstream station located downstream of the State Highway ZZ bridge, WFL7 = station located downstream of the Maple Road bridge, WFL6 = station located downstream of the State Highway E bridge, WFL5 = station located downstream of the State Highway PP bridge, WFL2 = station located upstream of the State Highway MM bridge.

4.4 Comparison to 2007/2008 Biological Assessment

4.4.1 Stream Habitat

Habitat score comparability percentages to the biological reference stream were similar between the assessment periods of 2007/2008 and 2015/2016. During each assessment period, scores were high at WFL2 and lowest at WFL8. Habitat at WFL8 was not "supporting" of the biological community during the 2007/2008 assessment period with only 72.9 percent comparability to the biological reference. In the 2016/2017 assessment period, WFL8 station could be classified as "supporting" with 76 percent comparability to the biological reference. In both assessment periods, lower habitat scores at WFL8 could be attributed to low pool variability, which was likely due to the lowest discharge at this station. In the 2016/2017 assessment, WFL8 also differed from the biological reference station in vegetative protection having low cover along channel banks and narrower riparian zone widths. Overall, habitat stability appeared to improve in the downstream direction.

4.4.2 Physicochemical Analysis

In both the 2007/2008 and 2016/2017 assessments, nutrients were elevated in West Fork Locust Creek stations. The current bioassessment study, however, had elevated nutrients (USEPA 2000) across more stations than in the 2007/2008 bioassessment study. Physicochemical parameters in both assessment periods were within the limits of Missouri's Water Quality Standards. These data indicate nutrients and turbidity are chronic issues in West Fork Locust Creek.

4.4.3 Macroinvertebrate Stream Condition Index (MSCI) Scores

MSCI values improved between the 2007/2008 bioassessment and the 2016/2017 bioassessment. One fall 2007 station (WFL7) and four spring 2008 stations (WFL5, WFL6, WFL7, and WFL8) had partially supporting MSCI scores, whereas in the 2016/2017 bioassessment, all stations, except WFL6 during the spring, had fully supporting MSCI scores. The MSCI scores increased in four of the five WFL fall and spring stations, which indicated macroinvertebrate communities improved in taxonomic diversity and the abundance of pollution-sensitive taxa.

4.5 Conclusions

West Fork Locust Creek improved in physical habitat and macroinvertebrate community composition in comparison to the 2007/2008 bioassessment. Only the nutrient and turbidity measures from the physicochemical analysis indicated areas of potential concern. Elevated nutrients can increase primary productivity and decrease stream oxygen levels (Chambers et al. 2012, Dodds 2006, Smith et al. 1999). Should nutrients remain chronically high, dominance by a few taxa may result in a decrease in the MSCI richness metrics of TR and EPTT (Chambers et al. 2012).

Tests of null hypotheses resulted in the following conclusions.

H_1: Habitat scores will not differ among stations.
This hypothesis was not supported. Scores gradually improved in the downstream direction, although all scores were classified similarly as supporting of biological life.

H_2: West Fork Locust Creek habitat scores will not differ from the reference stream habitat.
This hypothesis was not supported. The most upstream station of WFL8 could not be classified as "comparable to the reference" with a score of 79 and a similarity of 76 percent to the reference stream. However, remaining WFL stations were all more than 90% similar to the reference. Although the WFL8 habitat score was lower than the remaining test stations, it did meet the "fully supporting" threshold specified in the *Stream Habitat Assessment Project Procedure* (MoDNR 20126c).

H_3: Physicochemical measures will not differ among stations.
This hypothesis was not supported. Stations along WFL had a longitudinal arrangement with considerable distances between points of sample collection (distances between stations varied from 2 to 10 miles). Generally, nutrients and turbidity increased in the downstream direction, whereas dissolved oxygen increased in the upstream direction.

H_4: Physicochemical water quality measures will meet Missouri's WQS.
This hypothesis was supported. Physicochemical parameters in the fall and spring were within Missouri's WQS limits.

H_5: Physicochemical water quality measures will meet EPA nutrient criteria recommendations.
This hypothesis was not supported. Every WFL station had at least one nutrient and/or turbidity parameter in exceedance of recommended EPA levels in both sampling seasons.

H_6: The MSCI will indicate benthic communities are the same among stations.
This hypothesis was not supported. All scores did not indicate WFL stations in the fall and spring seasons were fully supporting of aquatic life. The only station that was partially supporting was WFL6 (however, see Section 4.3.1).

H_7: In comparison to the 2007 bioassessment of WFL, stations with a classification of "fully supporting" will not change.
This hypothesis was not supported. Stations that attained a fully supporting status in the 2007/2008 bioassessment still held the same status during the 2015/2016 bioassessment. Additionally, several WFL stations that received a partially

supporting status in the 2007/2008 bioassessment had a fully supporting status in 2016/2017.

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Appendix A

Fall 2016 Macroinvertebrate Taxa Lists

West Fork Locust Creek

Semi-quantitative kick net collections of macroinvertebrates from West Fork Locust Creek station 8 (WFL8), Sullivan County, Missouri, in the fall 2016. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

	Habitat		
Taxon	NF	RM	SG
AMPHIPODA			
Hyalella azteca		11	
BASOMMATOPHORA			
Physella	1	3	1
COLEOPTERA			
Agabus		1	
Dytiscidae		1	
Helichus basalis		4	
Helichus lithophilus		6	
Hydrophilidae		1	
Scirtidae		2	
DIPTERA			
Ablabesmyia		2	1
Chironomidae	1	1	5
Chironomus	4		
Chrysops		5	
Cladotanytarsus			7
Corynoneura	1		
Cricotopus bicinctus			3
Cricotopus/Orthocladius	2	1	3
Dicrotendipes	1		13
Forcipomyiinae	1		
Glyptotendipes			2
Gonomyia		2	
Kiefferulus		1	
Labrundinia	1		
Nanocladius	1		1
Paratanytarsus	1		1
Polypedilum fallax grp			1
Polypedilum flavum		1	
Polypedilum halterale grp	8		
Polypedilum illinoense grp	13	17	26
Polypedilum scalaenum grp	2		
Rheocricotopus		1	2
Rheotanytarsus		2	1
Saetheria		1	
Simulium		15	6
Stempellinella	6		4

	Habitat		
Taxon	NF	RM	SG
Stenochironomus			25
Tabanus		1	
Tanytarsus	13	7	29
Thienemanniella	1	1	1
Thienemannimyia grp.		1	2
Tipula		4	1
Zavrelimyia			2
EPHEMEROPTERA			
Acerpenna			2
Caenis latipennis	3	20	2
Heptagenia	1	21	14
Leptophlebiidae	1	1	
Procloeon			1
Pseudocloeon	1	3	11
Stenacron			1
Tricorythodes			1
HEMIPTERA			
Microvelia	1	1	
ODONATA			
Argia		5	
Calopteryx	4	36	
Progomphus obscurus	2	5	2
TRICHOPTERA			
Cheumatopsyche		59	4
Nectopsyche	1	5	
Ptilostomis		2	
TUBIFICIDA			
Tubificidae		5	1

Semi-quantitative kick net collections of macroinvertebrates from West Fork Locust Creek station 7 (WFL7), Sullivan County, Missouri, in the fall 2016. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

	Habitat		
Taxon	NF	RM	SG
HYDRACARINA			
Acarina	1		
AMPHIPODA			
Hyalella azteca		15	2
BASOMMATOPHORA			
Physella	1	14	1
COLEOPTERA			
Dytiscus	1		
Helichus basalis		7	
Helichus lithophilus		7	
Neoporus			1
Scirtidae		1	
DECAPODA			
Faxonius virilis		*	
DIPTERA			
Ablabesmyia	4	5	1
Ceratopogoninae	1		1
Chironomus	5		
Chrysops	1	1	
Cladotanytarsus	1		4
Clinotanypus	1		
Corynoneura		1	
Cricotopus bicinctus	1	1	16
Cricotopus/Orthocladius		1	
Cryptochironomus	8		
Cryptotendipes	2		
Dicrotendipes	1		8
Diptera	3		1
Forcipomyiinae			2
Hydrobaenus		1	
Labrundinia		2	1
Muscidae		1	
Nanocladius	6	10	2
Paracladopelma			2
Paratanytarsus	3		
Phaenopsectra	1		1
Polypedilum flavum			1
Polypedilum halterale grp	5		3

	Habitat		
Taxon	NF	RM	SG
Polypedilum illinoense grp	58	54	26
Polypedilum scalaenum grp	5		1
Rheocricotopus			2
Rheotanytarsus	2	8	
Saetheria			1
Simulium	8	8	23
Stempellinella	39	2	3
Stenochironomus			34
Tanytarsus	48	32	19
Thienemanniella	2	4	
Thienemannimyia grp.	1	4	
Zavrelimyia	2		
EPHEMEROPTERA			
Baetis			6
Caenis latipennis	10	12	4
Heptagenia	49	40	30
Leptophlebiidae	2	8	2
Maccaffertium pulchellum	1	1	
Paracloeodes			3
Pseudocloeon	4	14	21
Stenacron		2	2
Tricorythodes	2	6	2
HEMIPTERA			
Microvelia		6	
Neoplea	1		
ODONATA			
Argia		7	
Calopteryx		9	1
Enallagma		1	
Hetaerina		1	
Ischnura		3	
Libellula	1		
Progomphus obscurus	1		1
TRICHOPTERA			
Cheumatopsyche		22	9
Nectopsyche		13	
Oecetis		1	
Ptilostomis	1	1	
TUBIFICIDA			
Enchytraeidae	1	1	
Tubificidae	4	12	5

Semi-quantitative kick net collections of macroinvertebrates from West Fork Locust Creek station 6 (WFL6), Sullivan County, Missouri, in the fall 2016. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

	Habitat		
Taxon	NF	RM	SG
AMPHIPODA			
Hyalella azteca		25	7
BASOMMATOPHORA			
Physella		5	
COLEOPTERA			
Helichus basalis		4	
Helichus lithophilus		13	
Neoporus		6	
DIPTERA			
Ablabesmyia	1		
Ceratopogoninae			2
Chironomidae	3	2	3
Chrysops	1	10	
Cladotanytarsus	3		14
Cricotopus bicinctus			2
Cricotopus/Orthocladius		1	12
Cryptochironomus		1	
Dicrotendipes			30
Diptera			1
Forcipomyiinae			1
Glyptotendipes			2
Hemerodromia			1
Labrundinia			1
Microchironomus	1		
Nanocladius			2
Paratanytarsus		1	1
Pericoma	1		
Polypedilum flavum	1	4	2
Polypedilum halterale grp	1		
Polypedilum illinoense grp		21	12
Polypedilum scalaenum grp			1
Psychoda	1		1
Rheocricotopus			1
Rheosmittia	6		
Rheotanytarsus		8	4
Saetheria	3		
Simulium	3	17	16
Smittia	1		

	Habitat		
Taxon	NF	RM	SG
Stempellinella	10		3
Stenochironomus			24
Tanytarsus	3	5	56
Thienemanniella	1	1	1
Thienemannimyia grp.		7	3
Tipula		1	
EPHEMEROPTERA			
Acentrella			1
Acerpenna		1	1
Baetis	2		13
Caenis latipennis	3	21	15
Heptagenia		10	8
Leptophlebiidae		11	1
Maccaffertium pulchellum			2
Pseudocloeon		4	
Stenacron	6		15
Tricorythodes		1	3
HEMIPTERA			
Belostoma		*	
ODONATA			
Argia		15	
Boyeria		1	
Calopteryx		5	1
Enallagma		1	
Gomphidae		2	
Hetaerina		1	
Libellulidae		2	
Progomphus obscurus	1	*	
TRICHOPTERA			
Cheumatopsyche	1	93	7
Hydroptila			13
Nectopsyche		12	3
Ptilostomis		2	
TUBIFICIDA			
Tubificidae		4	2

Semi-quantitative kick net collections of macroinvertebrates from West Fork Locust Creek station 5 (WFL5), Sullivan County, Missouri, in the fall 2016. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

	Habitat		
Taxon	NF	RM	SG
AMPHIPODA			
Hyalella azteca	1	12	
BASOMMATOPHORA			
Physella		1	
COLEOPTERA			
Agabus		1	
Helichus lithophilus		2	
Laccobius	1	1	
Scirtidae		1	
Uvarus	1		
DIPTERA			
Ablabesmyia	10		
Anopheles		2	
Ceratopogoninae	1		
Chironomus	7		
Chrysops		4	
Cladotanytarsus	7		
Cricotopus/Orthocladius		2	
Cryptochironomus	1		
Dicrotendipes	2		10
Ephydridae	2		
Forcipomyiinae			1
Gonomyia	1		
Labrundinia		3	
Muscidae	1		
Nanocladius	2	5	
Parachironomus	2	5	1
Paracladopelma	3		
Paratanytarsus		1	
Phaenopsectra		1	
Polypedilum fallax grp			1
Polypedilum flavum	1	2	1
Polypedilum halterale grp	3		
Polypedilum illinoense grp	51	45	6
Procladius	2		
Pseudolimnophila		1	
Rheotanytarsus		11	1
Simulium	8	16	3

	Habitat		
Taxon	NF	RM	SG
Stempellinella	6	1	
Stenochironomus			10
Tanypus	1		
Tanytarsus	13	32	7
Thienemanniella		4	
Thienemannimyia grp.		2	1
Tipula	2		
Tribelos		1	1
Zavrelimyia	5	1	
EPHEMEROPTERA			
Acerpenna			3
Baetis			5
Caenis latipennis	20	43	4
Callibaetis	1		1
Centroptilum	2		
Heptagenia		46	
Isonychia		1	
Leptophlebiidae	3	14	
Maccaffertium pulchellum			4
Paracloeodes	3		
Procloeon	2		
Pseudocloeon		15	6
Stenacron	2	1	26
Stenonema femoratum	1	1	
Tricorythodes	3	15	
HEMIPTERA			
Microvelia	1	3	
Rheumatobates		1	
LUMBRICINA			
Lumbricina		1	
ODONATA			
Argia	1	16	
Calopteryx		8	
Enallagma		1	
Erythemis		1	
Gomphidae	1		
Ischnura	1		
Progomphus obscurus	8	1	
TRICHOPTERA			
Cheumatopsyche	1	25	37
Hydroptila			3

	Habitat		
Taxon	NF	RM	SG
Nectopsyche	6	38	
Ptilostomis		2	
TUBIFICIDA			
Limnodrilus hoffmeisteri	1		
Tubificidae		5	
VENEROIDA			
Pisidiidae		2	

Semi-quantitative kick net collections of macroinvertebrates from West Fork Locust Creek station 2 (WFL2), Sullivan County, Missouri, in the fall 2016. * = taxon found in large and rare; Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

	Habitat		
Taxon	NF	RM	SG
HYDRACARINA			
Acarina		2	
AMPHIPODA			
Hyalella azteca			1
BASOMMATOPHORA			
Ancylidae			1
COLEOPTERA			
Dubiraphia		1	
Optioservus sandersoni		1	
Stenelmis		1	
DIPTERA			
Ablabesmyia	1		3
Axarus	1		
Chironomidae		1	1
Cladotanytarsus	2		
Corynoneura	1	2	1
Cricotopus bicinctus			1
Cricotopus/Orthocladius			17
Cryptochironomus	6	1	
Cryptotendipes	2		
Dicrotendipes	1		38
Forcipomyiinae			4
Glyptotendipes		2	8
Labrundinia	1	3	1
Microchironomus	1		
Nanocladius		1	
Parakiefferiella			1
Paralauterborniella	2	1	
Polypedilum flavum	1		1
Polypedilum halterale grp	8	1	
Polypedilum illinoense grp	6	21	9
Polypedilum scalaenum grp			2
Pseudochironomus			4
Rheotanytarsus			2
Stelechomyia			2
Stempellinella	9		1
Stenochironomus			7
Tanytarsus	7	8	37

	Habitat		
Taxon	NF	RM	SG
Thienemannimyia grp.	2	5	10
Tribelos			8
EPHEMEROPTERA			
Acerpenna			3
Caenis latipennis	143	154	68
Centroptilum	1		
Hexagenia	1		
Maccaffertium pulchellum	4		
Paraleptophlebia		13	1
Pseudocloeon		2	
Stenacron		5	1
ODONATA			
Argia	1	14	
Calopteryx		1	
Enallagma		1	
Gomphidae	1	1	
Progomphus obscurus	1		
TRICHOPTERA			
Hydropsyche			4
Hydroptila			1
Nectopsyche	2	23	
Oecetis			1
Polycentropus			1
TUBIFICIDA			
Branchiura sowerbyi	45	2	
Limnodrilus hoffmeisteri			1
Tubificidae	20	2	3
VENEROIDA			
Pisidiidae	1	1	

Appendix B

Spring 2017 Macroinvertebrate Taxa Lists

West Fork Locust Creek

Kick net collections of macroinvertebrates from West Fork Locust Creek station 8 (WFL8), Sullivan County, Missouri, in the spring 2017. * = taxon found in large and rare; Habitats: CS=coarse substrate, NF=nonflow, RM=rootmat.

	Habitat		
Taxon	NF	RM	SG
COLEOPTERA			
Dytiscidae			1
Helichus lithophilus		1	
Hydrophilidae			1
Peltodytes	1		1
Scirtidae	1		
DIPTERA			
Ablabesmyia	4	2	1
Ceratopogoninae	7		1
Corynoneura	2		
Cricotopus bicinctus	12	33	9
Cricotopus/Orthocladius	24	105	20
Cryptotendipes	2		
Dicrotendipes	5	3	1
Gonomyia	3		
Hydrobaenus	14	2	3
Labrundinia		1	
Limnophyes		1	
Micropsectra		1	
Nanocladius	1	1	1
Paracladopelma	1		
Paraphaenocladius	1		
Paratanytarsus	1	5	1
Phaenopsectra	3	3	
Polypedilum flavum	1	4	
Polypedilum halterale grp	11		
Polypedilum illinoense grp	6	18	15
Polypedilum scalaenum grp	7		
Procladius	1		
Pseudosmittia	1		
Rheosmittia	10		
Rheotanytarsus	3	1	
Saetheria	7	1	1
Simulium	2	35	4
Smittia	1		
Tabanus	*		
Tanytarsus	124	79	11
Thienemanniella	6	2	2

	Habitat		
Taxon	NF	RM	SG
Thienemannimyia grp.	2	8	1
Zavrelimyia	4	2	1
EPHEMEROPTERA			
Acerpenna		1	
Baetisca lacustris			1
Caenis latipennis		1	
Heptagenia		10	2
Heptageniidae		2	
Leptophlebia	6	4	3
HEMIPTERA			
Microvelia			1
ODONATA			
Progomphus obscurus	2		
TRICHOPTERA			
Cheumatopsyche	1	1	
Triaenodes		1	
TUBIFICIDA			
Enchytraeidae	3		4
Limnodrilus claparedianus	1		
Limnodrilus hoffmeisteri	12	2	1
Tubificidae	4	1	2

Kick net collections of macroinvertebrates from West Fork Locust Creek station 7 (WFL7), Sullivan County, Missouri, in the spring 2017. * = taxon found in large and rare; Habitats: CS=coarse substrate, NF=nonflow, RM=rootmat.

	Habitat		
Taxon	NF	RM	SG
AMPHIPODA			
Hyalella azteca	4		
ARHYNCHOBDELLIDA			
Erpobdellidae	*		
COLEOPTERA			
Dytiscidae	1		
Dytiscus	1		
Peltodytes	2		
Uvarus	1		
DIPTERA			
Ablabesmyia	1	2	1
Ceratopogoninae	1		
Chironomidae	1		
Chironomus	1		
Chrysops	3		
Corynoneura	2	3	
Cricotopus bicinctus	2	17	1
Cricotopus/Orthocladius	41	117	120
Cryptochironomus	2		
Dicrotendipes	5	2	4
Diptera	6	1	
Gonomyia	1	1	1
Hydrobaenus	8	4	5
Labrundinia	1	1	
Muscidae			1
Paracladopelma	1		
Parakiefferiella	1		
Paralauterborniella	1		
Paraphaenocladius		1	
Paratanytarsus	3		
Phaenopsectra	1		
Polypedilum fallax grp	1		
Polypedilum flavum	2	1	
Polypedilum halterale grp	17		
Polypedilum illinoense grp	22	7	27
Polypedilum scalaenum grp	17		
Rheosmittia	3	1	1
Rheotanytarsus	2		

	Habitat		
Taxon	NF	RM	SG
Saetheria	1	2	1
Simulium	22	33	77
Stenochironomus	2		
Tanytarsus	38	37	24
Thienemanniella		3	4
Thienemannimyia grp.	3	9	3
Zavrelimyia		1	
EPHEMEROPTERA			
Acerpenna	2	1	2
Baetisca lacustris			1
Caenis latipennis		2	
Heptagenia	17	16	12
Leptophlebia	2	6	2
GORDIOIDEA			
Chordodidae	1		
Gordiidae	1		
HEMIPTERA			
Microvelia		1	
Sigara		1	
ODONATA			
Argia	1	1	
Calopteryx	2	1	
Progomphus obscurus	3		
RHYNCHOBDELLIDA			
Piscicolidae	2		
TRICHOPTERA			
Cheumatopsyche	1	2	
TUBIFICIDA			
Enchytraeidae	4	2	5
Limnodrilus hoffmeisteri	4		
Tubificidae	11		

Kick net collections of macroinvertebrates from West Fork Locust Creek station 6 (WFL6), Sullivan County, Missouri, in the spring 2017. * = taxon found in large and rare; Habitats: CS=coarse substrate, NF=nonflow, RM=rootmat.

	Habitat		
Taxon	NF	RM	SG
AMPHIPODA			
Hyalella azteca		6	
COLEOPTERA			
Enochrus		1	
DIPTERA			
Ablabesmyia		3	
Ceratopogoninae	5	6	1
Chironomidae	1		
Chironomus	1		1
Cladotanytarsus		4	
Corynoneura		3	
Cricotopus bicinctus	3	23	15
Cricotopus/Orthocladius	7	91	136
Cryptochironomus	3		
Cryptotendipes	1		
Dicrotendipes	2		2
Diptera	1		1
Hydrobaenus	3	9	3
Labrundinia		2	
Nanocladius		1	
Ormosia	1	2	
Paracladopelma	1		
Parakiefferiella			1
Paralauterborniella	2		
Parametriocnemus		1	
Paraphaenocladius			2
Paratendipes	1		
Phaenopsectra		5	1
Polypedilum halterale grp	4	1	
Polypedilum illinoense grp	3	13	24
Polypedilum scalaenum grp	6		
Pseudosmittia			1
Rheocricotopus		2	1
Rheosmittia	13	5	
Saetheria	2		
Simulium	10	4	14
Tanytarsus	12	60	15
Thienemanniella		1	

	Habitat		
Taxon	NF	RM	SG
Thienemannimyia grp.	1	2	1
Zavrelimyia	1	2	
EPHEMEROPTERA			
Acerpenna		1	
Baetisca lacustris			4
Caenis latipennis	1	3	
Heptagenia		1	2
Leptophlebia	1	11	3
HEMIPTERA			
Belostoma		*	
ODONATA			
Calopteryx		1	
Progomphus obscurus	1		
TUBIFICIDA			
Enchytraeidae	5	6	10
Tubificidae	4	1	1

Kick net collections of macroinvertebrates from West Fork Locust Creek station 5 (WFL5), Sullivan County, Missouri, in the spring 2017. * = taxon found in large and rare; Habitats: CS=coarse substrate, NF=nonflow, RM=rootmat.

	Habitat		
Taxon	NF	RM	SG
AMPHIPODA			
Hyalella azteca		4	
BASOMMATOPHORA			
Physella			*
COLEOPTERA			
Dytiscidae		1	
Helichus basalis			1
Scirtidae		1	
DIPTERA			
Ablabesmyia	6	9	
Ceratopogoninae	22	4	2
Chironomidae	2		
Chironomus	4	3	
Chrysops		1	
Cladotanytarsus	2	2	
Corynoneura	2		
Cricotopus bicinctus	7	31	8
Cricotopus/Orthocladius	70	117	114
Cryptochironomus	4		1
Cryptotendipes	6	1	
Dicrotendipes	5		7
Diptera	8	1	2
Ephydridae	1		1
Hydrobaenus	10	4	2
Labrundinia		2	
Limnophyes	1		
Micropsectra	1	1	1
Ormosia	7	1	2
Paracladopelma	2		
Paralauterborniella	8		
Paraphaenocladius	2	3	
Paratanytarsus	3	5	1
Paratendipes	1		
Phaenopsectra	6	1	1
Polypedilum fallax grp			1
Polypedilum flavum	2	5	4
Polypedilum halterale grp	3		
Polypedilum illinoense grp	8	15	18

	Habitat		
Taxon	NF	RM	SG
Polypedilum scalaenum grp	7		1
Procladius	2		
Pseudosmittia	1		
Rheocricotopus		1	2
Rheosmittia	3		3
Rheotanytarsus		3	1
Saetheria			1
Simulium	2	10	50
Smittia	1		
Stictochironomus	2		
Tanyderidae	2		
Tanytarsus	115	112	39
Thienemannimyia grp.		7	5
Zavrelimyia		1	
EPHEMEROPTERA			
Acerpenna			1
Baetisca lacustris	5	3	
Caenis latipennis	18	7	3
Heptagenia	1	10	10
Hexagenia	1		
Leptophlebia	4	9	4
Maccaffertium pulchellum		1	4
Stenacron	5		
ODONATA			
Calopteryx		1	
Gomphidae	*		1
PLECOPTERA			
Taeniopteryx		1	
TRICHOPTERA			
Cheumatopsyche	1	1	2
Nectopsyche		1	
TUBIFICIDA			
Enchytraeidae	19	1	1
Limnodrilus hoffmeisteri	2		
Tubificidae	8	2	

Kick net collections of macroinvertebrates from West Fork Locust Creek station 2 (WFL2), Sullivan County, Missouri, in the spring 2017. * = taxon found in large and rare; Habitats: CS=coarse substrate, NF=nonflow, RM=rootmat.

	Habitat		
Taxon	NF	RM	SG
HYDRACARINA			
Acarina		2	
COLEOPTERA			
Peltodytes		2	1
Scirtidae			1
DIPTERA			
Ablabesmyia	12	18	1
Ceratopogoninae		2	
Chironomidae	3		
Chironomus	13	1	
Cladotanytarsus	8		
Cricotopus bicinctus		7	
Cricotopus/Orthocladius	24	78	35
Cryptochironomus	7		1
Cryptotendipes	13		1
Dasyheleinae	1		
Dicrotendipes	6	3	2
Diptera	1		
Eukiefferiella			1
Hemerodromia			1
Hydrobaenus	2	5	3
Labrundinia		1	1
Nanocladius	3	3	
Paracladopelma	2		
Paralauterborniella	8		1
Paraphaenocladius	1		
Phaenopsectra	2		3
Polypedilum flavum			4
Polypedilum halterale grp	21		
Polypedilum illinoense grp	2	32	38
Polypedilum scalaenum grp	3		
Procladius	2		
Rheotanytarsus	1	4	3
Saetheria	3		
Simulium			5
Tanytarsus	106	99	25
Thienemannimyia grp.	2	6	5
Zavrelimyia	2	2	

	Habitat		
Taxon	NF	RM	SG
EPHEMEROPTERA			
Acerpenna		3	4
Baetisca lacustris	1	2	3
Caenis latipennis	37	32	18
Heptagenia	1	1	
Hexagenia limbata	6		
Leptophlebia	4	4	1
Maccaffertium pulchellum			4
Stenacron	1	1	
Stenonema femoratum	1		1
NEOTAENIOGLOSSA			
Lymnaeidae		3	
ODONATA			
Argia	2		
Calopteryx		1	
Nasiaeschna pentacantha			1
RHYNCHOBDELLIDA			
Piscicolidae	2		
TRICHOPTERA			
Cheumatopsyche		1	2
TUBIFICIDA			
Branchiura sowerbyi	9		
Enchytraeidae	1	9	1
Limnodrilus claparedianus	1		
Limnodrilus hoffmeisteri	2		
Tubificidae	8	2	
VENEROIDA			
Pisidiidae	2		